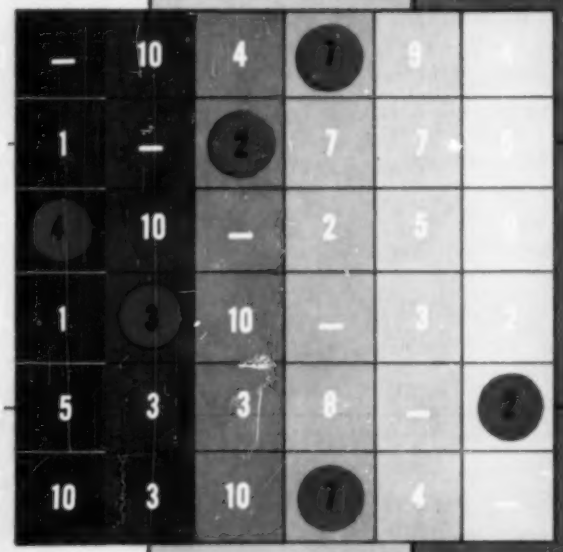
JANUARY 1957

CHEMICAL ENGINEERING PROGRESS

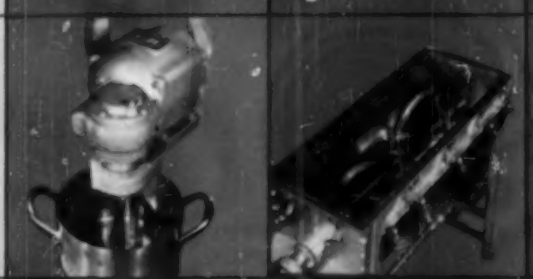


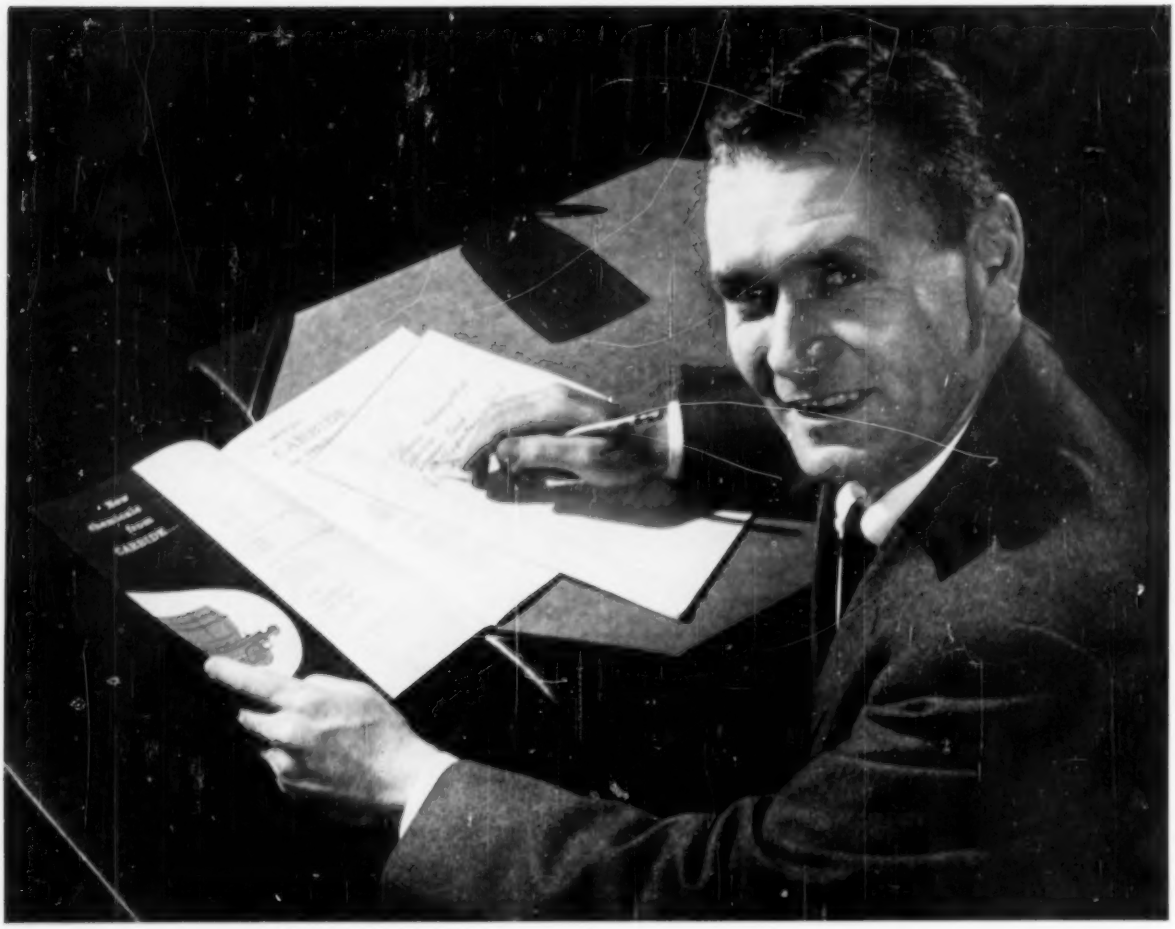
What, OPSEARCH is all about

PLUS:
Trends: Adjustment?
Hydrocarbon flammability
Nucleation
Are Engineers satisfied?
Cost of ion exchange

Management conference
The sales engineer
Research roundup:
annual thesis index

Which (dry solids) Mixer for the job?





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Chemical Engineering Progress

what's in this issue

January, 1957 • Volume 53, No. 1

Chemical engineering & Navy's technologic revolution / 8
Noted & Quoted—The Chief of Naval Operations reviews the profession's role in the Navy's transition.

Unionization among engineers / 22
The National Industrial Conference Board reports on its study, which analyzes factors which have led to unionization.

Do our students really try? / 26
Letters to Editor—Reader poses question, in commenting on Admiral Strauss' proposal for higher requirements.

Period of adjustment? / 49
Trends—With 1957 bringing record expansion of the chemical industry along with increasing problems, will there be serious adjustments, accelerated by steel shortage?

CEP SPECIAL CO-FEATURE

What OPSEARCH is all about

OPsearch and teamwork / 3-J
G. D. Creelman—This new scientific method of executive decision-aiding is a "natural" for the chemical engineer.

OPsearch—what it is, how conducted, what it will do / 4-J
R. L. Ackoff—The background, essential characteristics, and methods of operations research.

OPsearch and teamwork / 8-J
Richard Wallen—Unless groups of people can work creatively, OPsearch efforts are stymied.

OPsearch—the management point of view / 9-J
T. M. Ware—Complexities of modern industrial operations are cited as creating a profound need for OR.

OPsearch in process engineering / 11-J
A. R. Klingel, Jr., & C. L. Cornett—OR in the petroleum refining industry, as exemplified by Standard of Ohio.

OPsearch and a scheduling problem in a plant / 14-J
B. O. Marshall, Jr.—A case report on a Carborundum Co. machine used for making a variety of abrasive products.

Case studies in OPsearch / 17-J
Joseph Rio & A. F. Shorkey—An account of how operations research methods are being introduced at Dow.

(Continued on page 5) ——▶

departmental features

Noted and quoted / 8 • Letters to the Editor / 26 • About our authors / 32
Marginal notes / 38 • Opinion and comment / 1-J • Data service / 65
Future meetings / 77 • Candidates for membership / 114 • CEP camera / 116
News from local sections / 122 • People / 128 • Classified / 132 • News and notes of A.I.Ch.E. / 143

for sizing dry chemicals it's the BAR-NUN Sifter

with stainless steel product zone

Multiplies screening capacity in same floor space

In some plants, installation of a modern Bar-Nun Rotary Sifter has doubled or tripled screening capacity in the same floor space. The Bar-Nun provides up to 40 square feet of screen surface in a floor area only 3½ feet square . . . up to 70 square feet in slightly larger floor space!

And, every inch of screen surface is active and productive. The Bar-Nun's single plane, smooth rotary motion sets up a stratifying action that keeps the finest particles next to the screen, for rapid, thorough separations.

Another Bar-Nun feature for the chemical plant: the screens are totally enclosed in a dust-tight box constructed of corrosion-proof stainless steel panels mounted on cast aluminum frames. The box is quickly opened and screens easily removed for thorough cleaning. Screen frames may be stainless steel, magnesium, or wood.

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Many processes now require uniformly sized particles—for product quality control, or for efficient operation of production equipment. If this is true in your plant, a Bar-Nun Rotary Sifter will prove the lowest cost sifter over a period of years.

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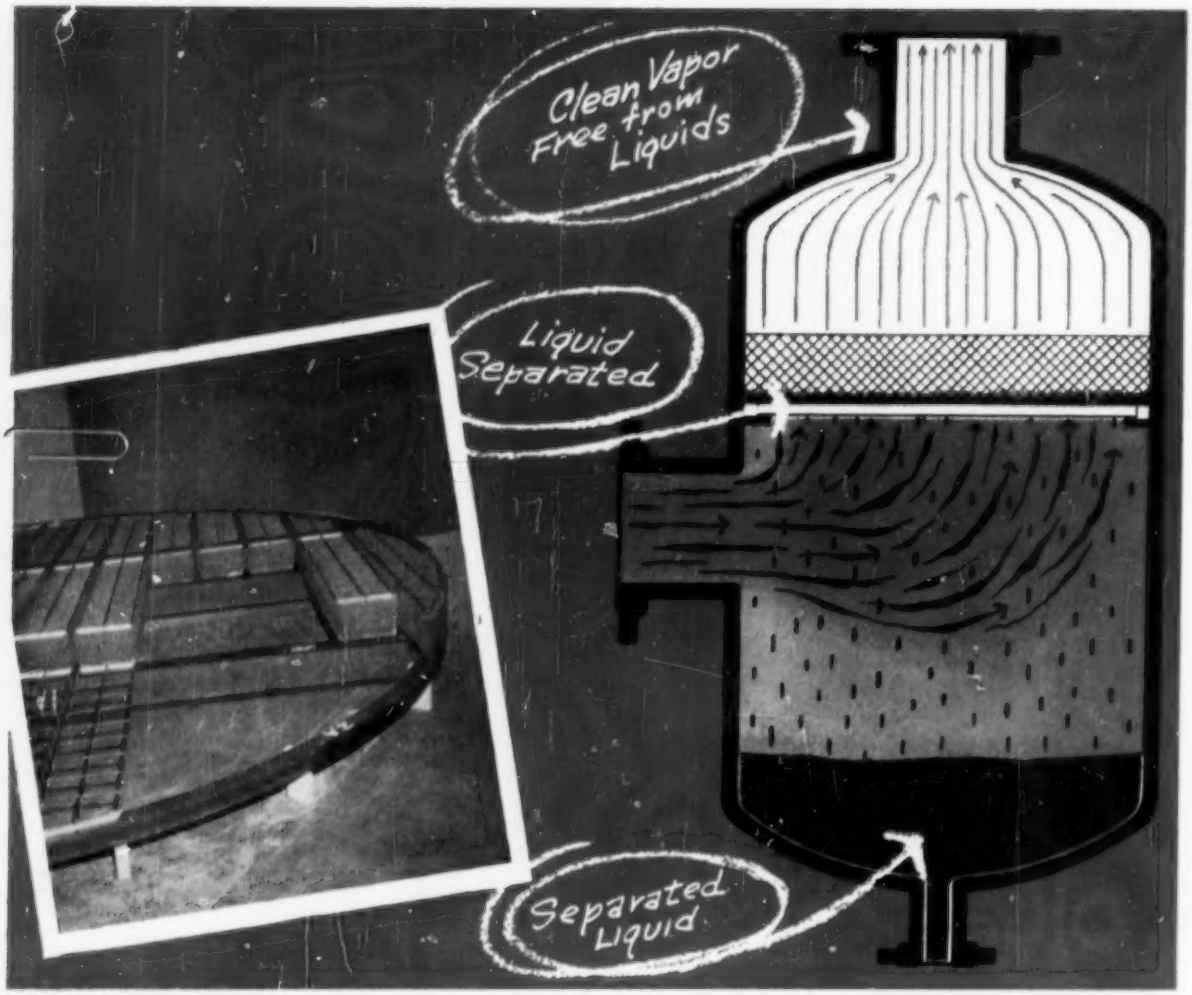

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In **distillation equipment** liquid entrainment is controlled, giving better quality overhead products even at increased thruput rates.

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Cover by Milton Wynne Associates

what's in this issue

(Continued from page 3)

Production planning—an OPsearch case study / 21-J
H. A. Hashbarger & N. L. Sample—A report on some of the activities of the Production Planning & Control section of Monsanto's Organic Chemicals Division.

CEP SPECIAL CO-FEATURE

Which (dry solids) mixer for the job?

Performance of dry-solids mixing equipment / 25-J
J. B. Gray—Mixing performance, a major consideration in the selection of equipment for a specific application, has been compared for several commercial types of machines.

Nucleation in oil-shale retorting / 33-J
M. W. Putman—"Cloud seeding" of rising oil vapors through a pebble bed has aided condensation of oil.

Costs of cation exchange equipment / 37-J
R. F. Peak & M. M. David—A compilation of data for applications where bed sizes, shapes, and flow arrangements are important variables.

Flammability limits for hydrocarbons at low pressures / 41-J
P. B. Stewart & E. S. Starkman—The ability of hydrocarbons to form explosive or combustible mixtures with air at atmospheric and lower pressures is reported.

What's happening in chemical engineering research? / 46-J
CEP's Annual Thesis Index—A compilation of the past year's university theses in chemical engineering.

What engineers expect from industry / 50-J
H. L. Rusch & J. R. Goeke—Report of an opinion survey, made of engineers in technical occupations.

Isocyanates move ahead / 52
Industrial News—National Aniline (Allied) places major new producing unit on stream at Moundsville.

Enriched uranium produced by private industry / 54
Industrial News—Mallinckrodt's new "custom shop" now producing U-235—enriched uranium dioxide.

Planning your March advanced training / 83
The month of March will offer two major opportunities for advanced training: in management, and in nuclear techniques. Better plan *now*, for arrangements, *then*.

A.I.Ch.E.'s Spring Management Conference / 84
J. Grossman & C. L. Dorsey, Jr.—The complete program of symposia and papers, including descriptions of contents.

E.J.C. Nuclear Congress and A.I.Ch.E.'s Atomic Exposition / 90
Last minute report on the events of significance.

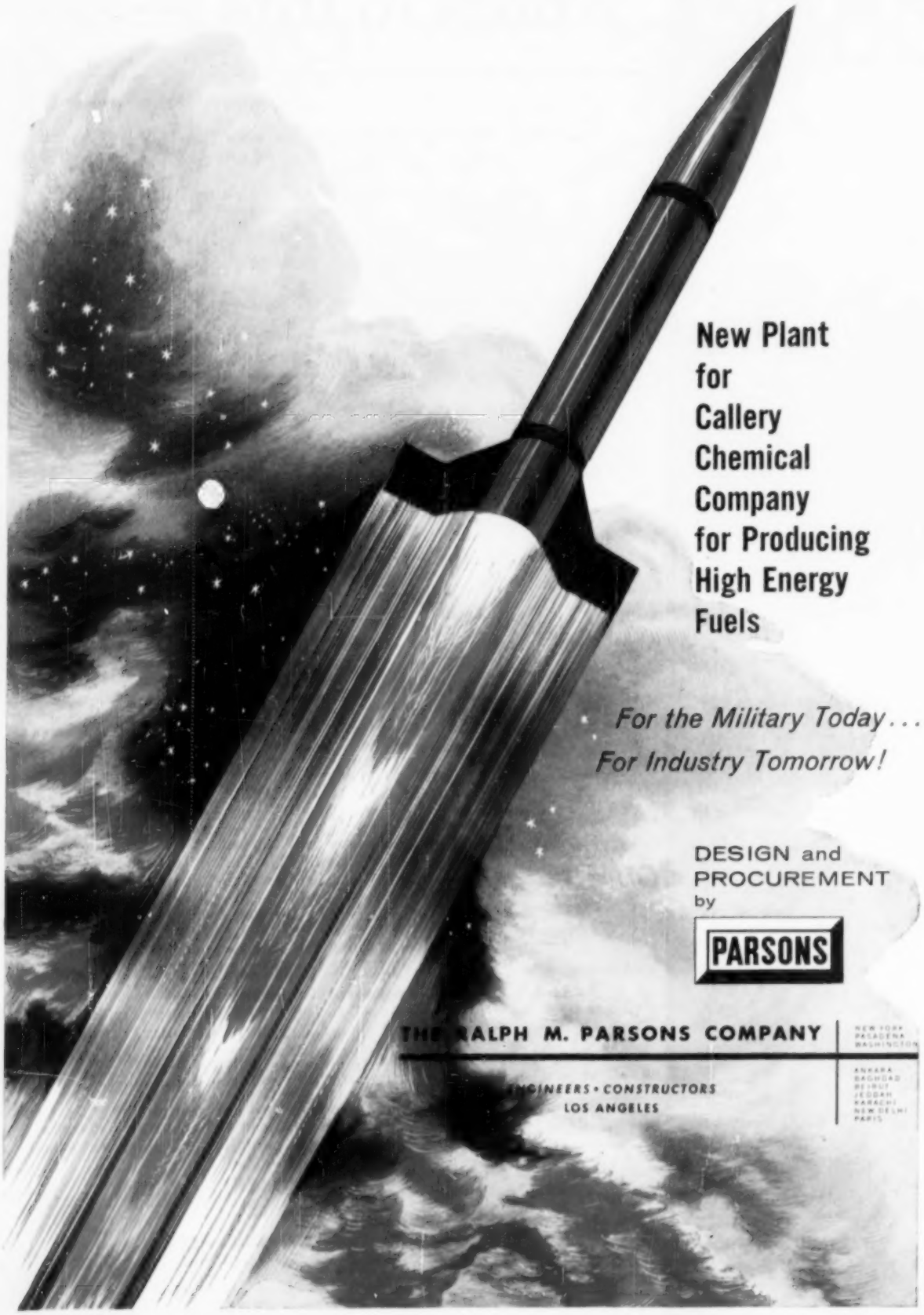
Performance yardstick for the chemical sales engineer / 94
How to judge the performance and reward the chemical engineer in sales is at least partially resolvable.

Industrial processes / 102
Paraxylene estimates; radio frequency synthesis excitation.

Now the retired will teach / 104
New York City completes arrangements.

Know of a "founder"? / 112
General call for information about those who were instrumental in the founding of A.I.Ch.E.

Developments arising from A.I.Ch.E. Annual Meeting / 143
News & Notes—Executive secretary Van Antwerpen reports in his column, a regular feature.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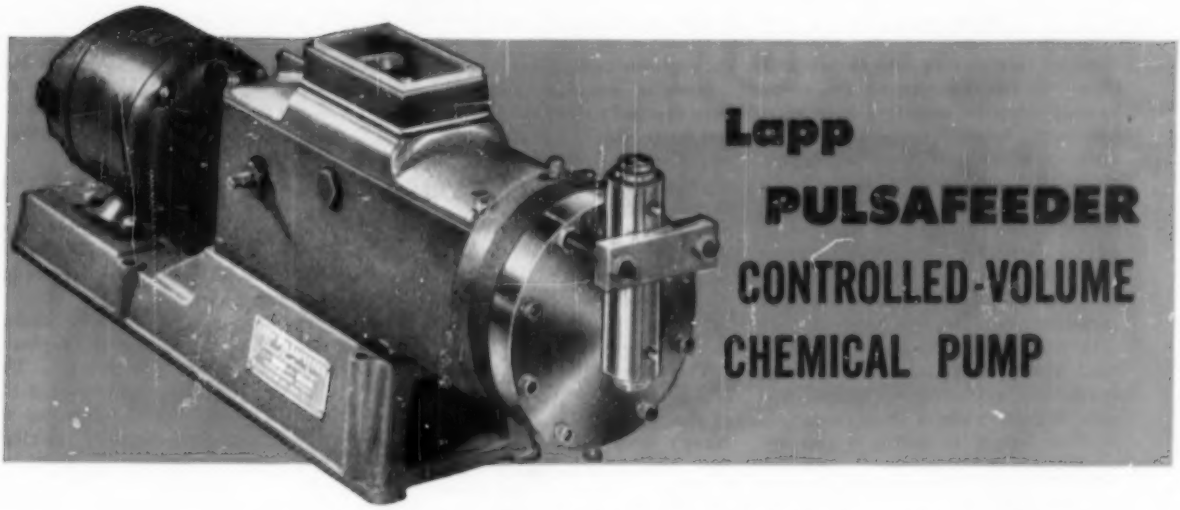

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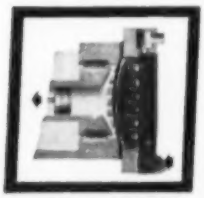

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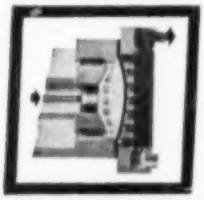
Positive displacement is achieved by a piston reciprocating within an accurately sized cylinder at an established stroke length, displacing an exact volume of hydraulic oil. By means of this oil, the piston moves the diaphragm alternately backward and forward. The displacement of this diaphragm travel takes in the liquid on the suction stroke of the piston and discharges a like amount of liquid on the discharge stroke of the piston.



DISCHARGE STROKE

WRITE FOR BULLETIN 440 *with typical applications, flow charts, description and specifications of models of various capacities and constructions. Inquiry Data Sheet included from which we can make specific engineering recommendation for your processing requirement. Write Lapp Insulator Co., Inc., Process Equipment Division, 692 Wilton Street, Le Roy, N. Y.*

Lapp

Noted and quoted

The role of chemical engineering in

THE NAVY'S TECHNOLOGIC REVOLUTION

Admiral Arleigh Burke * | Chief of Naval Operations

The Navy, like the chemical industry, is in a revolutionary era. New weapons, new equipment, and new techniques are being introduced into the Navy as fast as time and money will allow. As you can imagine, this revolutionary impulse occurring over wide technologic fields, plus the unique missions and environments of naval forces, has presented us with many technical problems. Naturally, we have turned to the engineer for support in solving these problems. The response has been gratifying. [Here are] some of the instances of how well you have answered the Navy's requests:

In most Navy equipment the technical problems fall into three general categories: performance, weight and size. A gain in one of these categories is often simple to obtain if you are willing to take a corresponding loss in one or both of the others. A simultaneous breakthrough in all three of them is exactly what the Navy always hopes the engineer can achieve.

Modern weapons and equipment have reached the point where size and weight are both critical, especially to the Navy, where the handling and storage problems aboard ships require us to use effectively every cubic inch of available space. . . .

The chemical engineer has been unique in his ability to help satisfy this Navy requirement. The current advances in propulsion and explosives are prime examples of such successes.

The future of air-breathing engines is a promising one, and the timeliness of the development in relation to the Navy's need is most fortunate. The new high-energy fuels developed for ramjets in missiles and aircraft enable the Navy to anticipate a fuel energy increase of about forty per cent in the next few years for the same volume load. This energy increase, naturally, carries with it corresponding speed and range increases. The toxicity of the basic fuel, which had made it unavailable for previous use, was resolved recently by a chemical engineer.

As a result, the Navy is now embarking on a $38 million project for the production of the resulting special compounds. And the Navy will continue to direct its research efforts further along these promising lines.

In the field of explosives, the search for lighter and more effective weapons has produced sizeable gains. For example, a new high explosive has been developed which produces a 25 per cent increase in the blast effect in our conventional bombs—and conventional bombs are still useful.

Similar advances have brought about a 50 per cent energy increase in the effectiveness of mines and torpedoes for undersea warfare—and undersea warfare is commencing to be more and more important.

Perhaps the most dramatic development in the conventional explosive field is the plastic-bonded PBX. This high explosive may be machined like a piece of inert material, and has the physical properties necessary to eliminate the need for steel encasement.

The Navy encounters a wide variety of problems on board ship. This, of course, is an understatement. Lighter materials for strength members, better fuels, lubricants, insulators, and protection against corrosion are a few of the present daily requirements of our fleets. Fleets must steam longer, faster and in a wider range of climatic conditions than ever before. (We have ships now in the Arctic, Antarctic, and all the way in between.) The Navy is counting on the engineer to continue to come up with the necessary answers.

A good example of how one of these problems was solved is found in the field of hydraulic fluids. The flammability of petroleum-based fluids clearly made this type too hazardous for the heavy load applications of today. As a result, the chemical industry came up with new fluids such as water-base glycerol and tri-aryl phosphate, non-explosive hydraulic fluids with the wider range of operating viscosities so urgently needed for present-day fleet equipment. The use of these fluids has greatly improved the efficiency of the hydraulic control systems in such equipment as missile launchers, periscope-elevating mechanisms and remote control of nuclear powered engines and steering systems.

In plastics, of course, the chemical

(Continued on page 10)

* Based on an address by Admiral Burke,† a chemical engineer and member of the A.I.Ch.E., at the 49th Annual Meeting of A.I.Ch.E., Boston, Massachusetts.

Stainless Breakthrough

The year 1956 will be looked on in the stainless steel industry as the break-through period for the 200 series of stainless steels when a phenomenal 850 per cent production increase was noted over the previous year. This means that 1956 will be remembered as the year when a substantial number of stainless fabricators learned to stretch scarce nickel supplies twice as far without sacrificing quality. (The 200 series is the chromium-nickel-manganese family of stainless steels which utilizes about one-half the nickel content of the more familiar 300 series.)

There were 1,886 net tons of the 200 series produced in 1955. This increased to more than 18,000 net tons in 1956.

The stainless industry continued to produce at a near record rate during the year and was expected to ship 680,000 net tons of finished mill products for 1956. This is less than one per cent below the all-time record high set by the industry in 1955, when 686,000 net tons were shipped. During the past year production and shipments were curtailed by a 34-day strike.

Information gained in a survey of sales of stainless steel by warehouses conducted by the industry showed that consumption is more diversified than previous data had indicated. For instance, industrial end uses account for 53.6 per cent of volume, as against 25.2 per cent for consumer products, and 21.2 per cent for all others. Stainless steel sales, the survey indicated, are more sensitive to capital equipment expenditures than to automotive production.

During the year shipments of stainless steel plate increased 58 per cent over the previous year; hot rolled bars went up 36 per cent; tubing 29 per cent; cold rolled sheet, 10 per cent; and heat resisting stainless steels, 21 per cent.

Condensed from statement by E. J. Hanley, President, Allegheny Ludlum Steel Corporation

Two Separate Circuits Mean

Reliable Rectifier Operation

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Mercury Arc Rectifiers

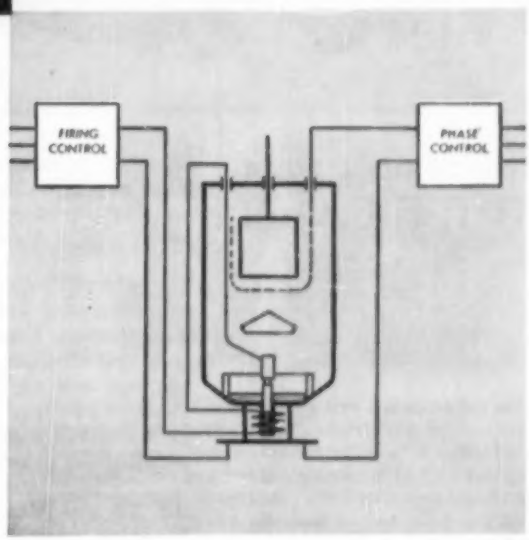
One of four metal-enclosed assemblies in a midwestern installation with a total capacity of 15,000 kw at 620 volts, dc.

1. Firing Circuit

A small dc excitation arc is automatically ignited only once, when the unit is started. It is then maintained on the mercury cathode of each rectifier tube. It offers advantages similar to a pilot light. Since it is far easier to maintain an arc than to start it, this feature reduces the chance of the excitron losing excitation during power supply disturbances.

2. Phase Control Circuit

A separate circuit utilizes the deionizing grid to obtain phase control. Grid-type phase control permits operation in the clean region near the anode where ion density is lowest, instead of on the surface of the cathode mercury pool where there is turbulence and contamination. Reliability of phase control does not depend on the condition of the mercury. This is an exclusive excitron feature.



Only Excitron Rectifiers Provide Separate Circuits

for these two all-important functions. Improved operation results — one function is never sacrificed for the other — you get optimum operation from each.

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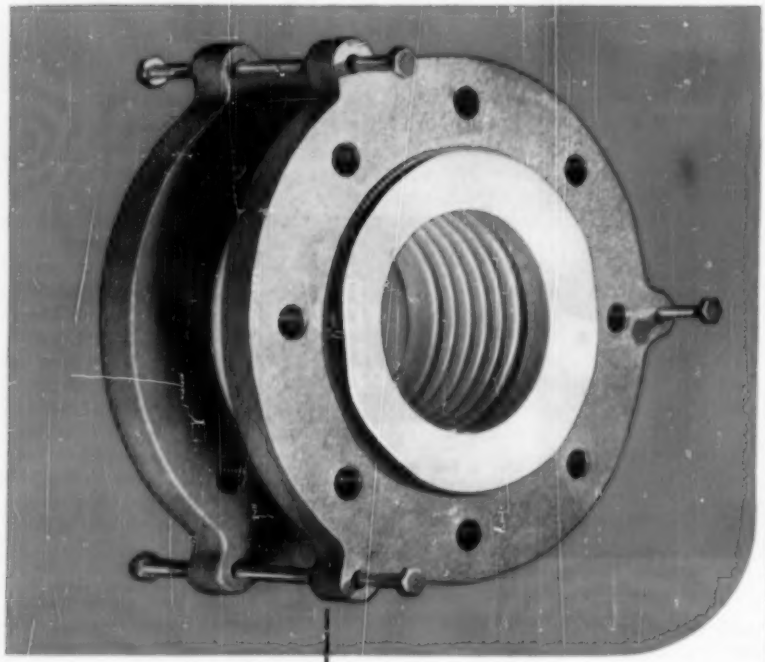
they supply the "GIVE and TAKE" for safe piping seals



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They absorb shock, vibration, thermal expansion and contraction. Correct misalignment. Connect unlike piping ends and nozzles. Eliminate gaskets, adaptors and slip joints. Are impervious to *all* chemicals excepting only molten alkali metals, fluorine under pressure and chlorine trifluoride.

All TEFLON Expansion Joints and Flexible Couplings are pressure tested at the plant . . . and flexural tested, too, for special requirements.

Write for Bulletin EJ-1155

UNITED STATES GASKET CO.

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Noted and quoted

(Continued from page 8)

industry is providing the Navy with an endless list of new applications. They range from the use of plastics in electron tubes to the plastic-hull construction of an 85-foot patrol craft which was recently authorized on an experimental basis. We are already using such material in topside structures aboard ship instead of steel and aluminum.

With such help, the Navy's guided missile family is growing rapidly. The Talos, Terrier, and Tartar, aboard guided missile cruisers such as the *Boston* and *Canberra* and aboard guided missile frigates and destroyers such as the recently-commissioned *Gyatt*, will soon constitute an effective anti-aircraft screen around our fleets in any type of war, big or little—reaching any plane at any altitude.

Air-to-air missiles such as the Sidewinder and Sparrow are already in operating squadrons. These missiles greatly increase the potential of our naval jet interceptors in aerial combat. The Fleet Ballistic Missile is also coming along (Mark 15, Mark 20).

The Navy is depending more and more on the guided missile. This, in effect, means that the Navy is depending more and more on the chemical engineer.

The Most Unforgettable Character (I never met)

Condensed from an address delivered at Pittsburgh National Meeting, A.I.Ch.E.

R. P. Genereaux

Du Pont

How often it seems that the people who have been the greatest, the happiest, and the most successful in the history of the world have been those who have possessed the quality of high and lofty discontent! This kind of discontent appears to be the result of a vision of what we might be, and what the world might be. And history is the record of the lives of men and women of all ages who must have been filled with this discontent, and who, in some field of human endeavor, devoted their lives to serving their vision of perfection.

So it was with the man who was to become one of our first technol-

(Continued on page 14)

S/K apades in industry

HOW TWO ENGINEERS BEAT THE HEAT AND SOLVED AN ODOROUS PROBLEM

The locale—the plant of a manufacturer of soap and allied products. The pressing problem—a 110° F temperature combined with ammonia fumes, produced during the making of Theobromine, which made working conditions unbearable in a section of the plant.

"Let's (kof-kof) look at the bright side, boss," suggested Shorty, the assistant plant engineer. "After all (kof), it could be worse (kof) . . . I know a guy who works in a meat rendering plant and if you think this situation smells, you—"

"SMELLS—SCHMELLS," screeched Barney, plant engineer and boss. "I KNOW (squrk) WHAT I THINK (hack). I THINK IF THIS SITUATION ISN'T SOLVED SOON, YOU'LL—*rendering plant?* You said rendering plant. SAY, didn't I see something about how an SK Fume Scrubber solved a fume problem in a rendering—"

"Boss, you're right," called Shorty on his way to the office.

"HERE IT IS!" shouted Shorty, reading, "SK FUME SCRUBBER ELIMINATES OBNOXIOUS FUME PROBLEM. Say, let's get an SK engineer in here."

And, they did. In no time at all, an SK Sales Engineer arrived, made an on-the-spot survey of the situation, and recommended the immediate installation of an SK 36" Fume Scrubber.

AND A BONUS—Now, air cooling and fume removal are both accomplished by the Fume Scrubber. Hot air and fumes pass through the scrubber where the ammonia fumes are removed and the hot air cooled. The air then passes through a scrubber box (equipped with SK Spray Nozzles), is further cooled, passes through heaters which raise its temperature to 70° F and reduce humidity to 70%, and returns clean and cool, to the building. The only operating cost is that for power to pump the pressure water which comes from a nearby quarry and well.

MORAL: *Chemical processing, food, or petroleum refining—no matter what business you're in—get acquainted with SK Fume Scrubbers. Send for Bulletin 4-R. Make use of a jet apparatus specialist, your nearest SK Sales Engineer.*

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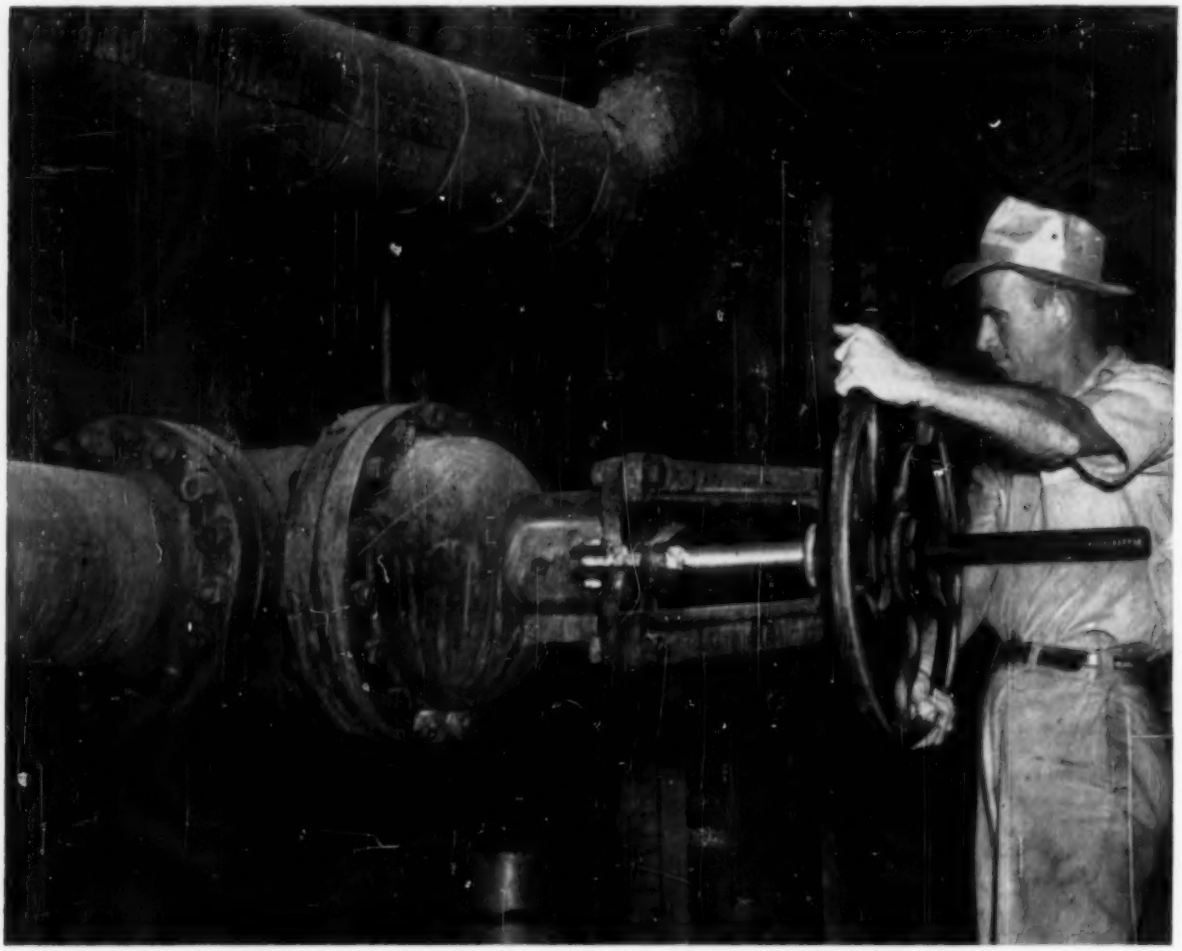
ROTAMETERS & FLOW INDICATORS: Ask for Condensed Bulletin 18-RA.
VALVES: Ask for Condensed Bulletin V-1.
HEAT TRANSFER APPARATUS: Ask for Condensed Bulletin HT-1.
GEAR PUMPS: Ask for Bulletin 17-A.

These Crane Valves Excel on Secondary Digester Blowdown



Crane 10-inch, 300-lb. No. 33XL cast steel gate valve with 18-8 liners installed on digester in major paper mill, handling corrosive liquors at 100 psi., 400°F.

"Too tough for hot, corrosive liquors"

. . . That's the report this major paper mill gives on Crane No. 33XL cast steel gate valves.

Up to 6 years ago, the mill was forced to replace secondary digester blowdown valves on every shutdown. Corrosion worked the body seat rings loose, made valve closure impossible.

Why did these Crane 33XL valves eliminate this costly maintenance problem? Because the body seat rings, liners and flange faces of these valves are 18-8 SMo alloy, integrally welded—making them tough enough to withstand the hot, corrosive liquors.

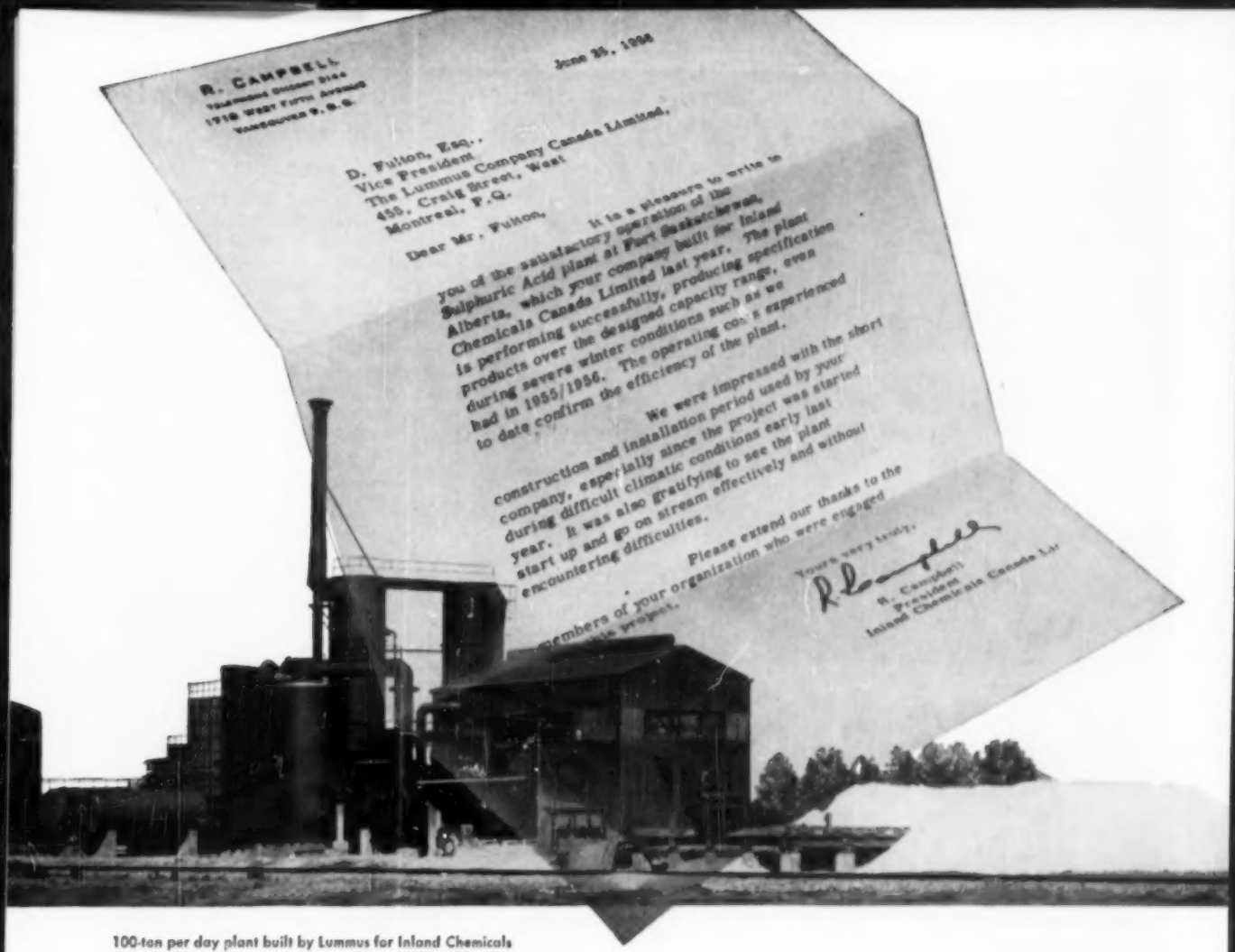
When you buy valves on price alone—or because they "look good enough"—you're gambling with your production. Be sure: choose your valves and fittings from the big, complete, strictly quality Crane line—first choice of industry for a century.

You may spot cost-saving ideas in this book of "Valve Performance Facts"—32 case histories throughout industry. Ask your Crane Representative, or write for a copy.

CRANE VALVES & FITTINGS

PIPE • PLUMBING • KITCHENS • HEATING • AIR CONDITIONING

Since 1855—Crane Co., General Offices: Chicago 5, Ill. Branches and Wholesalers Serving All Areas


R. CAMPBELL
June 25, 1956
D. Fulton, Esq.,
Vice President
The Lummus Company Canada Limited,
455, Craig Street, West
Montreal, P.Q.
Dear Mr. Fulton,
you of the satisfactory operation of the
Sulphuric Acid plant at Fort Saskatchewan,
Alberta, which your company built for Inland
Chemicals Canada Limited last year. The plant
is performing successfully, producing specification
products over the designed capacity range, even
during severe winter conditions such as we
had in 1955/1956. The operating co s experienced
to date confirm the efficiency of the plant.
construction and installation period used by your
company, espe ially since the project was started
during difficult climatic conditions early last
year. It was also gratifying to see the plant
start up and go on stream effectively and without
encountering difficulties.
Please extend our thanks to the
members of your organization who were engaged
Yours very truly,
R. Campbell
President
Inland Chemicals Canada Ltd

100-ton per day plant built by Lummus for Inland Chemicals Canada Limited went onstream 9½ months after the contract was signed, 7 months after field work began.

This sulfuric acid plant was—

Finished fast... started smoothly... is going fine!

Winter is rugged at Fort Saskatchewan, Alberta. In spite of it, this $1,000,000 sulfuric acid plant built there by Lummus was completed well ahead of schedule, and was making specification product within 12 hours of startup.

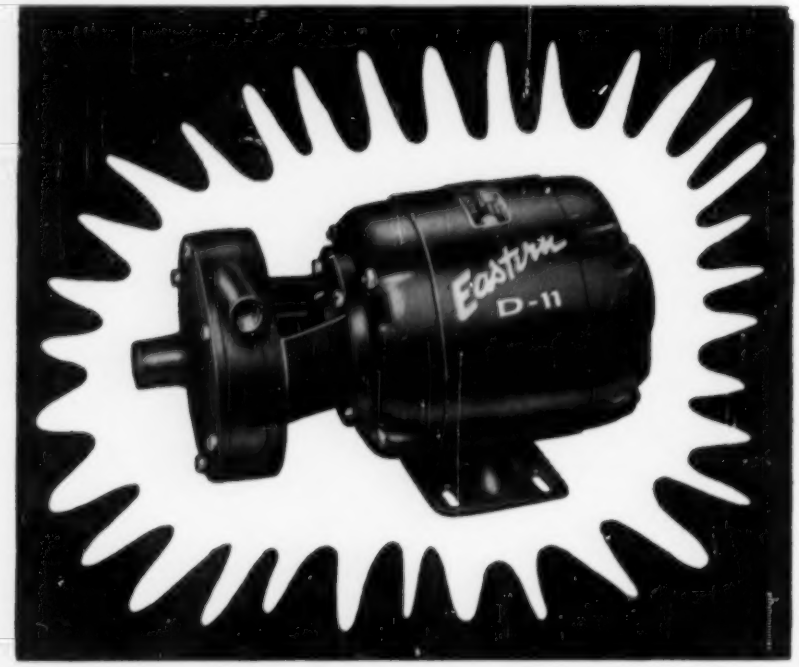
That was a year ago. Since then this plant has been producing to specification over a range of capacities from 45 to 125% of design.

Why not talk to Lummus before you start your next project?

THE LUMMUS COMPANY, 385 Madison Avenue, New York 17, N. Y.
Engineering and Sales Offices: New York, Houston, Montreal, London, Paris, The Hague, Bombay.
Sales Offices: Chicago, Caracas.
Heat Exchanger Plant: Honesdale, Pa.
Engineering Development Center: Newark, N. J.

LUMMUS

ENGINEERS AND CONSTRUCTORS FOR INDUSTRY



24,830 successful installations!

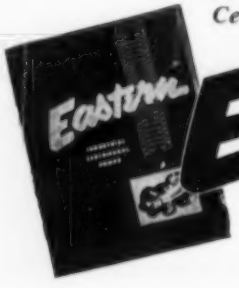
EASTERN D-11 CENTRIFUGAL PUMP

Why is the D-11 so successful among original equipment manufacturers? *Size and weight* make it ideal. The D-11 is the smallest, close-coupled, single-stage centrifugal pump available with an induction type motor. Eighteen pounds of compact design (9¾" x 4⅝") make it excel in industrial and process equipment, as well as laboratory service, and pilot plant operations.

SPECIAL METALS

A full selection of metals make the D-11 and other Eastern Centrifugal Pumps versatile performers. Available in 18-8 Type 303 and Type 316 Stainless Steel, Monel, Hastelloy "C", Cast Iron and Bronze, Eastern Pumps range from ⅛th to ¾ H.P. with capacities up to 70 G.P.M., pressures to 65 P.S.I.

For complete specifications on all Eastern Centrifugal Pumps, request Bulletin 120-A



Eastern INDUSTRIES, INC.
100 Skiff St., Hamden 14, Conn.

Noted and quoted

(Continued from page 10)

ogists, the man about whom this writing is directed. His urgent, passionate curiosity dominated every instant of his waking life. He worked in almost every field at one time or another in his life, and many of his discoveries were wholly his own. He was highly creative, and more; he was as much a promoter as an originator. If he saw something he liked, he took it, adapted it, and served it up anew, generally in a simpler, more immediate form.

Communicator

To communicate his ideas and discoveries, he found it necessary, as have many modern technologists, to improve his talent for expressing himself in writing. He went about this, as he did everything, methodically. Having chanced on an odd volume of a contemporary magazine, noted for the quality of its contents, he read and reread it with delight. He decided at once that he wanted to write in its style. He tried imitating the manner of one of its greatest writers in essays on his own subjects. He then compared his writings with that of the magazine and corrected his faults. Soon he realized his vocabulary was too meager and found an ingenious way of enriching it. From experience he knew that in writing verse you had to search for words to fit the rhyme scheme. He therefore turned his essays into verse, and then back again into prose, an exercise which quickly built up a new and permanent stock of words.

Early scientists, like too many of us today, had a tendency to create long and difficult words to describe new phenomena, but this man believed in simplicity and wide understanding, often poked fun at this tendency towards complexity, stating that those guilty did so only to impress themselves and please their own self-importance.

His own delight in communicating his discoveries to his friends convinced him that Americans should write each other continually about their observations of methods of agriculture, of soil, minerals, fossils, and animal breeding, and of other physical facts in the various parts of the country. They should instantly communicate knowledge of new mathematical techniques, of chemical discoveries and mechanical inventions, of geographic explorations and surveys and geolog-

(Continued on page 18)

Plating klystron tube parts at Electronic Tube Division, Sperry Rand Corp., Gainesville, Fla.

How Sperry Rand cuts plating wastes from 72,000 to 400 gallons per day

After plating, parts for Sperry Rand's 20,000-watt tubes for military air-navigation systems must be rinsed in high-grade water . . . the chemical equivalent of distilled water . . . and lots of it. But one pass through, and this pure water picks up toxic cyanides and can't be used again.

Dumping 72,000 gallons of toxic rinse water every day would contaminate the plant water supply. Chemical treatment to make this rinse water non-toxic would take up too much space . . . cost too much to build and operate.

So, Sperry Rand's engineers put in a PERMUTIT ion-exchange system that *removes* the copper, nickel, silver, cyanides and other impurities so the rinse water can be re-used.

Results: Dumping was cut to about 400 gallons per day of concentrated impurities in safely disposable form. And the same Permutit units also produce the equivalent of distilled water – in volume, at low cost–for cleaner, top-grade plating.

In the same way, ion-exchange cuts costs in anodizing, bright dipping, pickling, brass etching, copper stripping. It also recovers copper and zinc from rayon wastes, concentrates uranium from complex ores, removes impurities from sugar, drugs, antibiotics.

We'll be glad to show you how ion-exchange will improve your processing and products. The Permutit Company, Dept. CEP-1, 330 West 42nd Street, New York 36, N. Y., or The Permutit Company of Canada, Ltd., Toronto 1, Ontario.

PERMUTIT®

rhymes with "computs it"

ION EXCHANGE for Water Conditioning
Chemical Processing • Industrial Waste Treatment

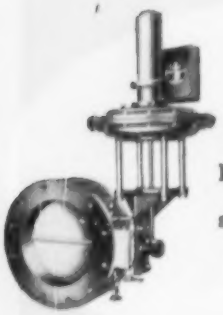
Needle Valves

Rugged, outstanding performers for proportional control of small flows. Interchangeable seat rings and plugs. For water, gas, steam, chemicals. Trim and body materials available for "difficult" fluids. Shown here with unique *reversible* Stabilflo Motor.

GET THE BEST

Saunders Type Valves

A complete line, particularly suited to handling of highly corrosive fluids, or fluids containing solids in suspension. Available with Stabilflo Motor as shown, or with Stabiload Cylinder and Power Positioner.

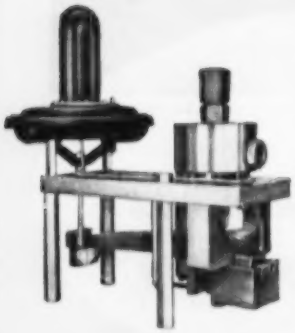


Butterfly Valves

Light and heavy duty types, with angle or swing-through seating, in spool or wafer body style, for low pressure air, gases in combustion control, steam, high pressure gases and liquids, etc. Available with Stabilflo Motor (shown) or cylinder operator.

Gate Valves

Guillotine-type slide valves, specially designed to handle pulp fibre, slurries, and similar fluids. Available with Stabiload Cylinder and Power Positioner as illustrated, for throttling service, or with 4-way pilot valve for on-off service.



Super-Pressure Valves

For throttling or let-down service up to 30,000 psi. Features an exclusive high-pressure bellows seal. Port sizes and connections to meet high pressure process specifications.

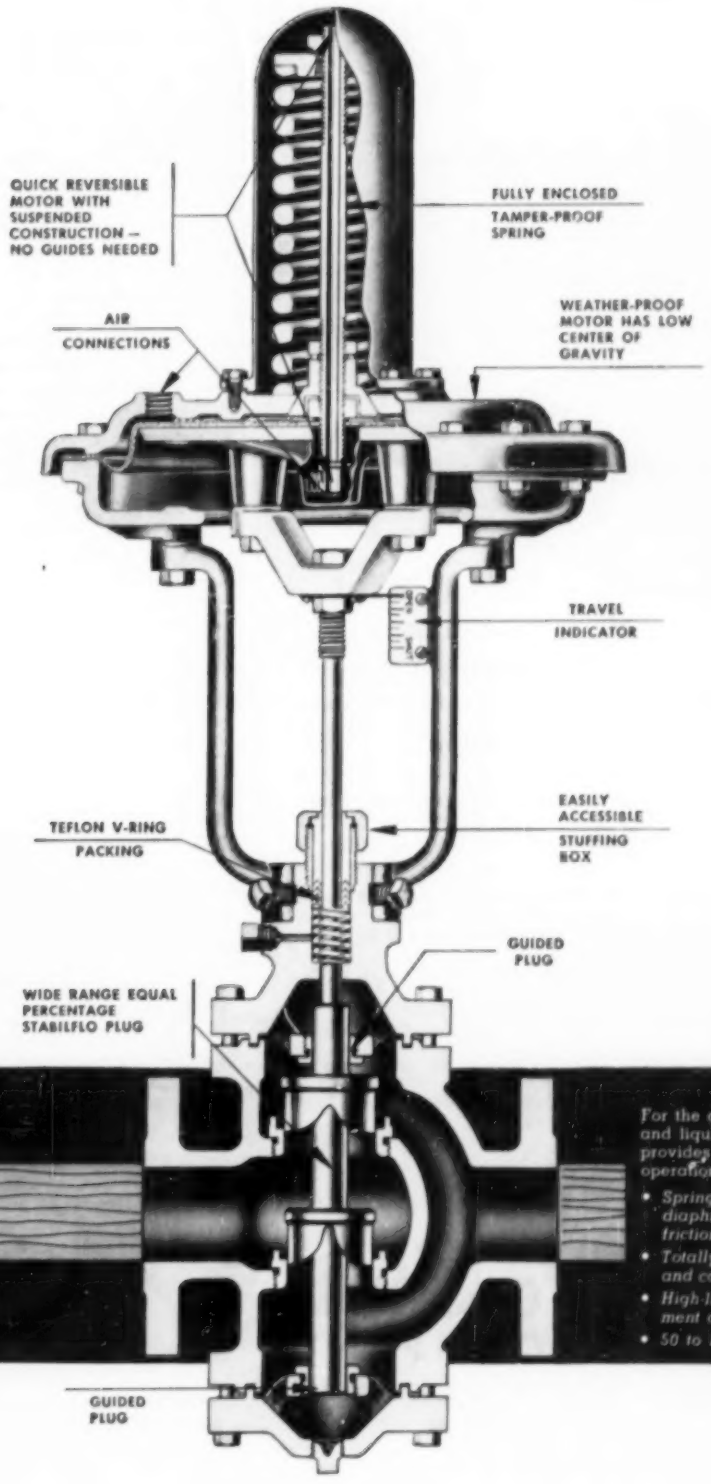
FOXBORO CONTROL VALVES

Reg. U.S. Pat. Off.

8 Strategic Branch Shops for Coast-to-Coast Service: **Pittsburgh, Pa. • Chicago (Skokie), Ill. • Dallas, Tex. • Houston, Tex. • San Francisco (San Leandro), Cal. • Los Angeles, Cal. • Montreal, Que. • Vancouver, B. C.**

SOLUTION TO YOUR CONTROL VALVE PROBLEMS

...with Foxboro Pneumatic Control Valves


QUICK REVERSIBLE MOTOR WITH SUSPENDED CONSTRUCTION — NO GUIDES NEEDED
FULLY ENCLOSED TAMPER-PROOF SPRING
AIR CONNECTIONS
WEATHER-PROOF MOTOR HAS LOW CENTER OF GRAVITY
TRAVEL INDICATOR
EASILY ACCESSIBLE STUFFING BOX
TEFLON V-RING PACKING
GUIDED PLUG
WIDE RANGE EQUAL PERCENTAGE STABILFLO PLUG
GUIDED PLUG

You can always be sure of getting the control valve best suited to flow conditions and control actions when you specify Foxboro. No other single source offers such a wide variety of control valves for specific applications. None other has Foxboro's experience in applying them — in every phase of industrial processing.

Your choice extends from valves for simple on-off control at one extreme, to specialized proportioning control at the other; for high vacuum work to operation at 30,000 psi; for temperatures from −350° to +1000°F. And there's a wide choice of plug designs — and of alloys and trim to handle even severely corrosive and erosive fluids.

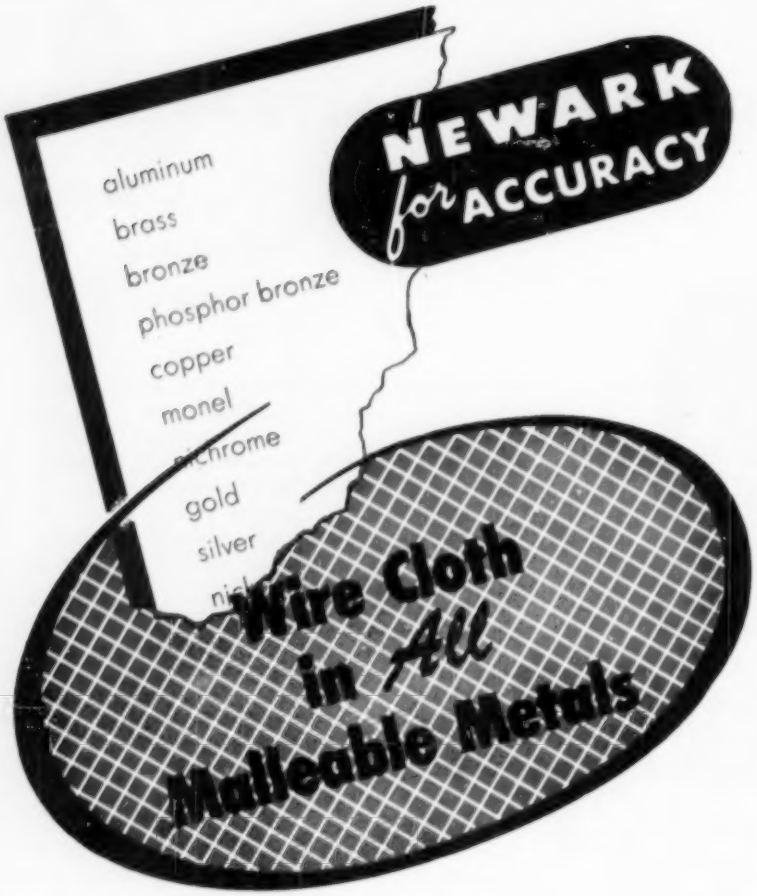
You can save shipping cost and time, too, buying direct from Foxboro's strategically located branch shops. They're staffed by experts.

A few typical control valves from Foxboro's complete line are illustrated here. For full details, or specific information on your problem, call your nearby Foxboro Field Engineer or write **The Foxboro Company, 931 Neponset Ave., Foxboro, Mass.**

STABILFLO CONTROL VALVES

For the great majority of temperature, pressure, flow, and liquid level control applications, this basic valve provides unsurpassed sensitivity and troublefree operation. *Unique design features:

- *Spring-above-diaphragm construction makes diaphragm motor self-aligning, virtually free from friction and hysteresis.*
- *Totally enclosed spring protects against tampering and corrosion.*
- *High-lift wide range V-port provides greater increment of lift for given change in air pressure.*
- *50 to 1 rangeability - equal percentage characteristics.*



Newark Wire Cloth is made of *all* malleable metals such as aluminum, brass, bronze, phosphor bronze, copper, monel, Nichrome, nickel and stainless steel; as well as the noble metals such as gold, silver, platinum, etc.

This wide range of metals enables you to select the one wire cloth to meet your conditions of corrosion and/or contamination.

In all metals, Newark Wire Cloth is accurately woven in a wide range of meshes, ranging from very coarse (4 inch space cloth), to extremely fine (up to 400 mesh). Our reputation for 'Accuracy' through more than 75 years is your guarantee of wire cloth quality.

We maintain a large stock of popular sizes in the more commonly used metals and can make prompt shipment. Let us quote on your requirements.

Send for our New Catalog E.

Newark Wire Cloth COMPANY

351 VERONA AVENUE • NEWARK 4, NEW JERSEY

Noted and quoted

(Continued from page 14)

ical findings, "and of all philosophical experiments that let light into the nature of things, tend to increase the power of man over matter, multiplying the conveniences or pleasures of life."

Career Programmer

This early technologist has been called "that intellectual bee which pollinated so many minds and groups of minds." With only two years of formal education and no social advantages, he dared to dream of a world wherein all men had a free and equal right to success through private enterprise. He not only dared to dream, but proved his theories himself in science, industry, education, and government.

To start his career, he drew up at the age of twenty a plan by which he regulated his future conduct. He wrote: "Let me make some resolutions and form some scheme of action, that henceforth I may live in all respects like a rational creature." His were pretty restrictive rules, and history tells us that his adherence to them was good indeed.

His self-control began while a youth, when he discovered his "bad habit" of violent or angry disputation. It was natural for the precocious boy to lord it over inferior minds, contradicting and confuting. But he gradually recognized that this had the effect of "souring and spoiling the conversation" and perhaps of producing (as he said) "enmities where you may have occasion for friendship." So he disciplined himself "in terms of modest diffidence," putting his would-be contradictions in the form of inquiries, and never laying down the law on any subject, no matter how well he might know it.

Prophet

For evidence of how completely far-seeing and accurate our man was, take these three sentences he wrote to the great Joseph Priestly: "The rapid progress true science now makes occasions my regretting sometimes that I was born so soon. It is impossible to imagine the height to which may be carried in a thousand years the power of man over matter. . . . O that moral science were in a fair way of improvement, that men would cease to be wolves to one another, and that human beings would at length learn what they now improperly call humanity."

This was the scientist, scholar, diplomat, and prophet Benjamin Franklin (1706-1790).

News from
National Carbon Company
A Division of Union Carbide and Carbon Corporation • 30 East 42nd Street, New York 17, N. Y.
Sales Offices: Atlanta, Chicago, Dallas, Kansas City, Los Angeles, New York, Pittsburgh, San Francisco. IN CANADA: Union Carbide Canada Limited, Toronto

PROCESS EQUIPMENT BRIEFS

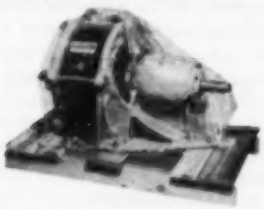
New heat exchanger sizes

A steady progression of unit capacities – in eight standard sizes having from 17.7 to 162.2 sq. ft. of heat transfer surface – is now available from stock in "Karbate" impervious graphite heat exchangers, "Series 90A" and "Series 310A". Units have interchangeable end assemblies with choice of 1, 2, 3, 4 or 5 pass arrangements.

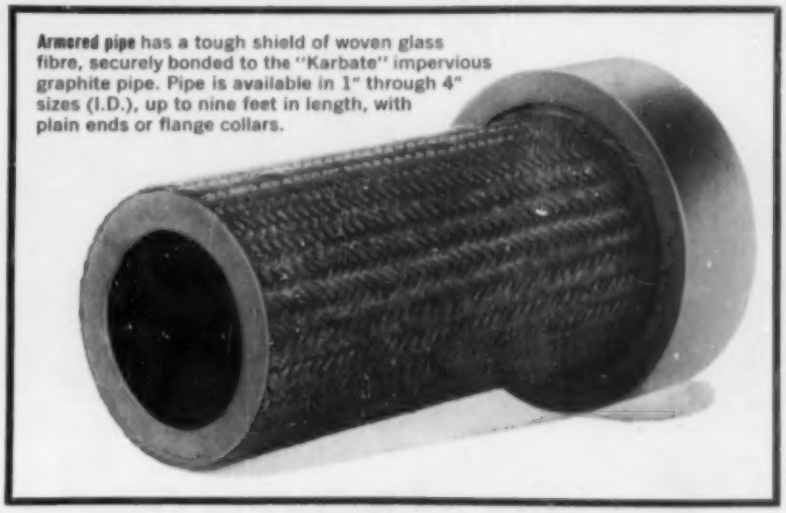
For details on these popular, low-cost corrosion-resistant units, request **Catalog Section No. S-6740.** Data on larger "Karbate" impervious graphite shell and tube heat exchangers (up to 3515 sq. ft.) are given by **Catalog Section No. S-6800.**

Carload shipment of "Karbate" pumps

Increasing use of "Karbate" impervious graphite for transfer and circulating services is demonstrated by shipment of a carload of "Karbate" centrifugal pumps for use in rayon spin bath service. Here, where 15% H_2SO_4 at 200°F. is handled, the use of "Karbate" pumps will eliminate possibility of metallic contamination.



Packaging of "Karbate" pumps is convenient, too. Covered with vinyl film, each pump is securely anchored on a pallet and crated. Complete instructions on installation and operation are sent with each pump. For further information, ask for **Catalog Section No. S-7250.**



Armored pipe has a tough shield of woven glass fibre, securely bonded to the "Karbate" impervious graphite pipe. Pipe is available in 1" through 4" sizes (I.D.), up to nine feet in length, with plain ends or flange collars.

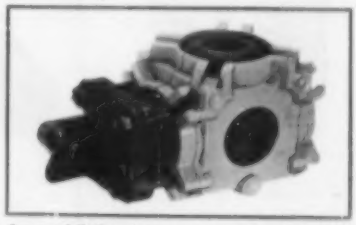
New "KARBATE" Armored Piping Gives Extra Safety with Corrosives

Greatly increased resistance to mechanical shock and strain is now a property of "Karbate" impervious graphite pipe and fittings. The reason: a newly-developed external armoring of tough, woven glass-fibre securely bonded to the pipe itself.

The most important result of this new idea in corrosion-resistant piping is the increased safety it provides in the handling of hot or corrosive liquids. In addition to increasing the resistance of "Karbate" pipe to accidental breakage, the closely-woven glass-fabric armoring remains intact even if the pipe should happen to be broken, holding line pressure . . . preventing potentially dangerous gross leakage.

Of course, this new line of "Karbate" armored pipe and fittings exhibits all the properties that have earned "Karbate" impervious graphite products wide acceptance in the chemical process industries: outstanding corrosion resistance . . . freedom from metallic contamination . . . resistance to thermal shock . . . ease of fabrication and installation.

For dimensions and other data on "Karbate" armored pipe and fittings, request **Catalog Section No S-7005.** Technical advice and assistance are also readily available.



Armored fittings have cast iron housing which not only armors the impervious graphite body but isolates it from any tensile or flexural stresses resulting from misalignment, vibration or expansion and contraction. Joint between pipe and flange collar has high strength because glass fibre sheath extends well into collar counterbore.

Adsorption a basic step in processing

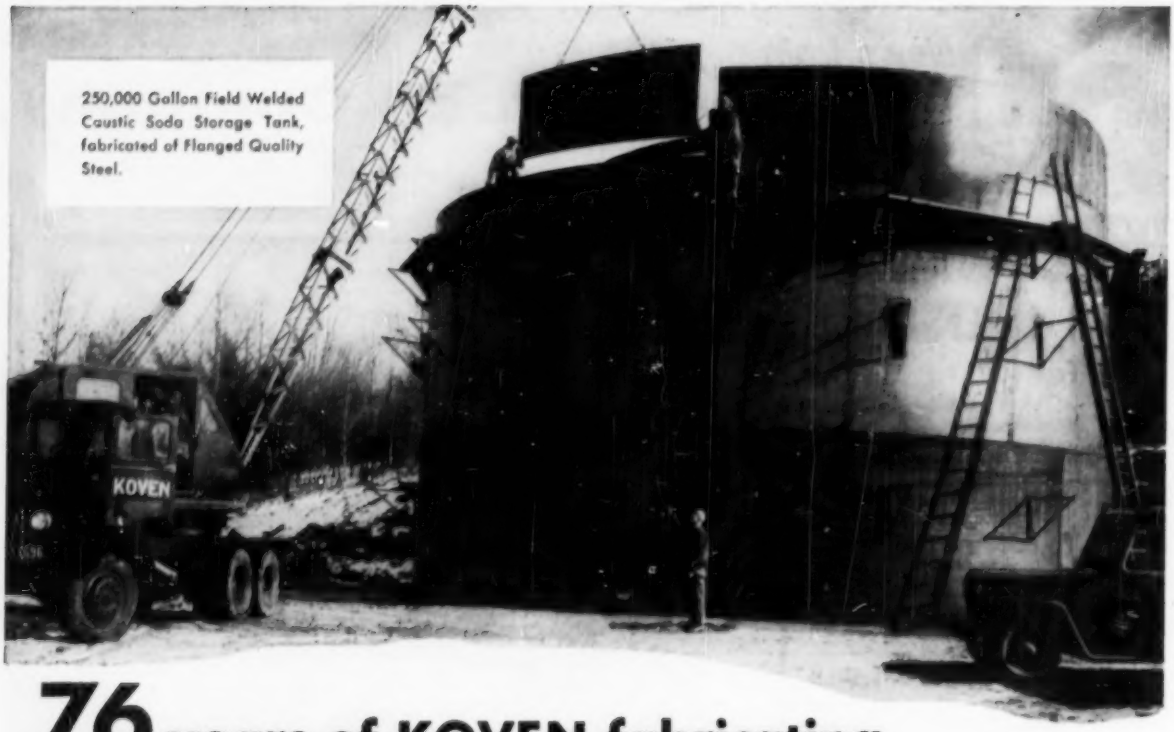
Accumulated experience reveals that adsorption is a basic unit operation in chemical engineering technology. Its familiar applications include gas purification, air conditioning, solvent recovery and many other specialized uses.

As a carrier of finely dispersed catalysts, the adsorbing agent plays another useful role. In addition, it can act as a catalyst itself—forcing a reaction in a desired direction by adsorbing one of the products.

For a new booklet **(Catalog Section S-6450)** on the use of "Columbia" activated carbon in these applications, write National Carbon Company, 1300 Lakeside Ave., Cleveland 14, O.

NATIONAL
TRADE MARK

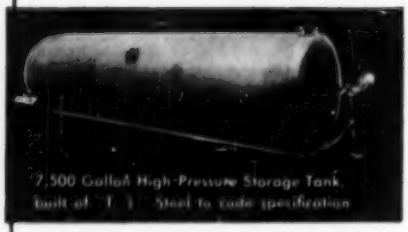
The terms National, "N" and Shield Device, "Karbate" and "Columbia" are registered trademarks of Union Carbide and Carbon Corporation.



250,000 Gallon Field Welded Caustic Soda Storage Tank, fabricated of Flanged Quality Steel.

76 years of KOVEN fabricating *Experience* built into every job

10' diameter x 20' high, Stainless Steel Jacketed Digester, built for 250 lb. working pressure. All seams 100% X-rayed.



7,500 Gallon High-Pressure Storage Tank, built of [illegible] Steel to code specification

X-RAY INSPECTION FOR QUALITY CONTROL

KOVEN equipment in all metals and alloys includes: High pressure vessels built to A.S.M.E., A.P.I. Codes; extractors; mixers; stills; kettles; tanks; stacks; breechings; hot transfer lines; large diameter fabricated piping and plate exhaust ducts; shop and field erected storage tanks; high vacuum testing.

SPECIALISTS IN INTRICATE FABRICATION USING:

- STAINLESS STEEL • ALUMINUM
- MONEL • NICKEL • INCONEL
- ALL CLAD MATERIALS
- NICKEL PLATED STEEL

Fabrication to all A.S.M.E. Codes

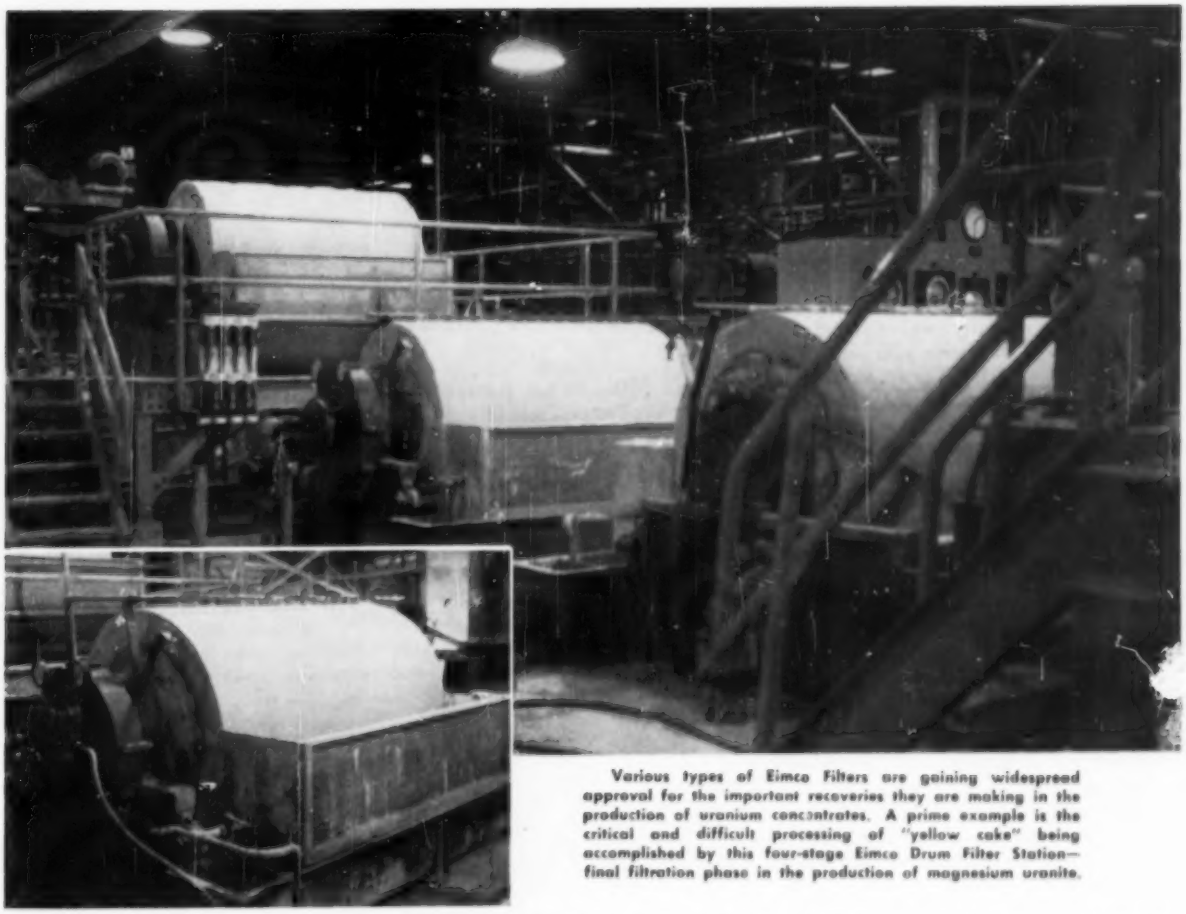
Nickel Plated Steel Fractionating Columns for use with Alkali Processing; 4' diameter x 40' long.

Call or write for a consultation with a trained KOVEN representative, and send for Bulletin #550.

See Sweet's Catalog File and Chemical Engineering File

Koven

KOVEN FABRICATORS, INC.
91 E. Dickerson St., Dover, New Jersey
Telephone: FOxcroft 6-0400
PLANTS: JERSEY CITY, N. J. • DOVER, N. J. • TRENTON, N. J.



Various types of Eimco Filters are gaining widespread approval for the important recoveries they are making in the production of uranium concentrates. A prime example is the critical and difficult processing of "yellow cake" being accomplished by this four-stage Eimco Drum Filter Station—final filtration phase in the production of magnesium uranite.

EIMCOS FILL TOUGH ROLE FOR URANIUM FIRM

A Canadian Uranium Corporation relies on a four-stage Eimco Drum Filter Station to wash and filter a uranium precipitate in the production of dry magnesium uranite.

The processing method used on mined ore includes a sulphuric acid leach on 55 to 62% minus 200 solids followed by a two-stage drum filtration to separate pregnant liquor from gangue solids.

After clarification and ionic exchange processes, the uranium is precipitated with magnesium oxide in a batch operation, and the slurry is thickened prior to final processing. The precipitate goes thru an initial filtration stage and three subsequent stages of repulping and filtering.

In these filtering stages, the main objective is removal of chloride contamination from the yellow cake. The Eimco Drum Filters are performing very satisfactorily under operating conditions made extremely difficult by physical characteristics of the solids.

The thin cakes exhibit severe cracking tendencies and are very adhesive, which makes washing and cake discharge difficult.

Washing becomes ineffective when wash water is short circuited thru cracks in the cake. To minimize this adversity, Eimco Drum Filters permit washing close to the slurry level, assuring a moist cake surface.

Eimco's roller-type discharge assembly gets complete cake removal that cannot be achieved by a scraper. The rollers exert a preferential sticking force at the discharge point, completely ejecting the yellow cake. Even though a scraper is set in contact with the medium, it does not get complete removal and medium life is short.

By combination of displacement, dillution and washing in three stages, 98% of the contaminate is removed with 100% recovery of solids.

Eimco's follow-up and service policy has resulted in better performance than the customer ever anticipated.

Let Eimco's Research and Development Center at Palatine, Ill., work hand in hand with you to solve your filtration problem.

THE EIMCO CORPORATION

SALT LAKE CITY, UTAH

Research and Development Division, Palatine, Illinois • Process Engineers Inc. Division, San Mateo, California
Export Offices: Eimco Building, 51-52 South Street, New York 5, N. Y.
BRANCHES AND DEALERS IN PRINCIPAL CITIES THROUGHOUT THE WORLD

B-231

N. I. C. B. reports on

UNIONIZATION AMONG ENGINEERS

The National Industrial Conference Board has completed a study and issued a report on unionism among engineers. Substantially an analysis of the factors which have impelled some engineers to join unions, and the areas in which unions purport to serve their professional members, the report also embodies many of the findings and recommendations of Engineers Joint Council.

CONCLUSION: NICB finds there is a sufficiently large area of dissatisfaction among engineers employed in industry today to warrant the taking of serious steps to improve the situation.

Engineering unions now claim as members nearly 60,000 American engineers out of the 500,000 listed in the U.S. Census of 1950. This factor undoubtedly weighed in NICB's decision to make a "round-up" survey of just what factors are causing engineers to join unions, what engineering unionism is, and what the engineer's professional societies and business managements attitudes toward unionism are.

While the 60,000 engineers claimed as members by the various unions is not large enough to consider engineers an organized group (particularly since in most cases the term "engineer" is somewhat loosely used to cover technicians not on the professional level) and although there is no significant evidence cited in NICB's Report to indicate growth of this group, the figure is considered significant enough by NICB to indicate possible wide dissatisfaction among engineers over present employment conditions, which, unless resolved in other ways, may result in more engineers seeking resolution of their grievances through collective bargaining.

* NATIONAL INDUSTRIAL CONFERENCE BOARD is a non-profit, fact finding organization for research in business economics and business management. It is supported by over 3,000 members and associates consisting of companies government agencies, labor unions, and other business organizations.

Areas of Dissatisfaction

By questioning executives of companies whose engineers are unionized, officials of engineering unions, representatives of engineering societies (such as EJC and the National Society for Professional Engineers), and engineers themselves, and by embodying information from other reports, notably EJC's report on Raising Professional Standards and Improving Employment Conditions for Engineers (May, 1956, and reproduced in full in NICB's report), the Conference Board has come up with a report which finds engineer dissatisfaction to be in three main areas today: 1) salary; 2) professional status; 3) individual status.

SALARY DISSATISFACTION

A major engineer complaint was found to be the narrow earnings differential between the salaried engineer and the wage worker, and between the senior engineer's salary and the beginner's salary. (In addition, traditional fringe benefits between engineers and production workers seem to have vanished.) Glowing, high pressure advertisements by companies seeking engineers are cited as tending to make the engineer feel that his company does not pay as well as other companies. And there is a strong feeling, referred to in the report, that merit is sometimes subordinated to seniority in determining salary increases.

PROFESSIONAL STATUS DISSATISFACTION

Engineering unions, engineering societies, and much of management are reported by the Board as taking stands which in substance agree that there is definite professional dissatisfaction among engineers today. Much of this is the loss of status the engineer feels he has lost with the mass employment of engineers.

The societies (based on a report by EJC) feel that reasons for professional status discontent among engineers are: 1) want to be classified as part of management but don't often get this; 2) lack of communication between top management and the lower echelon of engineers results in the engineers having a poor understanding of company policies; 3) some companies group engineers with non-professionals; 4) credit in reports and papers he helps develop is often denied the engineer, blocking professional recognition; 5) engineers are often denied sufficient opportunity to be active or hold office in their professional societies; 6) engineers are frequently hired for, or assigned to, jobs which do not call for engineering skill.

INDIVIDUAL DISSATISFACTION

NICB confirms the finding that most unionized engineers work for the relatively few firms that hire engineers in large numbers. (Most of these are in the aircraft and electrical industries.) This, essentially the disappearance of the old personal, professional relationship between engineer and employer, is considered by many as a primary cause of most engineering unionization. Other factors are: the engineer feels he often has no measure of progress such as job titles; he feels he is given insufficient training or job rotation so that he can progress; often he feels he has no way to make his complaints known and thus secure redress; and too often, according to EJC, he seems to have a "feeling of insecurity in employment."

The Engineering Unions

According to NICB's report, engineers largely backed into unionization by forming professional societies within companies to prevent being lumped with production workers under the old Wagner Act (which condition was eliminated by the so-called "professional clause" of the Taft-Hartley Act, which prevents intermingling of professionals with non-professionals in organized groups). In time these associations themselves took on the form of unions. Today, 13 such small associations are amalgamated into the Engineers and Scientists of America which claims 30,000 engineer members. There are other small, independent associations, and the chief AFL-CIO entrant, the American Federation of Technical Engineers, which claims 15,000 members, tends to include non-professionals, and is at present conducting a vigorous, well-financed campaign for engineer members. Finally, many engineers are organized into the

(Continued on page 26)

to re-create **perfect tone** . . . EXON 480

typical of the "Pin-Pointed Properties" in Exon vinyl resins

Exon engineers have combined properties so precisely in Exon 480 that they have created the specific resin for phonograph records.

A "biscuit" compounded of Exon 480 assures the finished recording of unusually high tonal quality, as well as breakage resistance.

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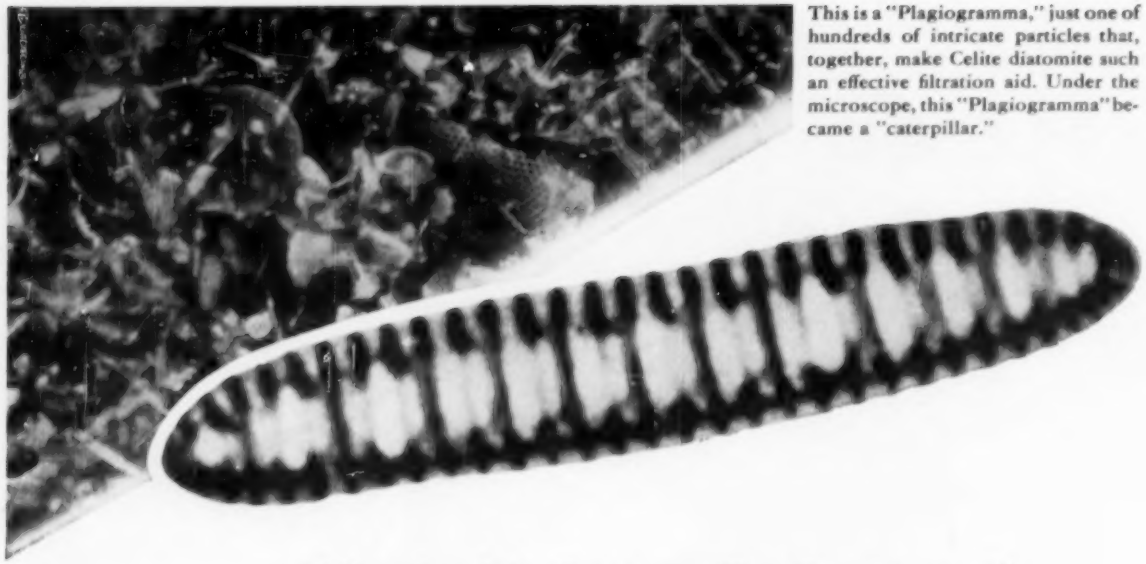

This is a "Plagiogramma," just one of hundreds of intricate particles that, together, make Celite diatomite such an effective filtration aid. Under the microscope, this "Plagiogramma" became a "caterpillar."

What's this "caterpillar" got to do with lower filtration costs?

It's a particle of CELITE that covers more

Assures highest purity in pharmaceuticals

Among the many important uses of Celite diatomite filter aids in industry today is the vital part they play in the production of life-saving antibiotics. Not only does Celite safeguard the purity of aureomycin, streptomycin and other pharmaceuticals; they also provide substantial cost savings that permit wider usage of these *wonder drugs*.

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Celite helps control pollution through removal of suspended solids from plant waste waters. Celite treatment often permits plants to reuse this water.

Provides greater clarity in varnish, lacquer and shellac

Celite filtration provides the high degree of clarity required in clear finishes. Celite is also widely used by the paint industry as a flatting agent and pigment extender.

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Many food processors make an important *sales plus* of the outstanding brilliance that Celite provides. Celite also helps increase juice yields as a pressing aid.

–the diatomite filter aid

filter surface per pound

THAT'S RIGHT. Celite* is the diatomite that gives you superior clarification at fast flow rates PLUS lower wet density. And lower wet density simply means greater surface coverage per pound of Celite. Which means substantial savings to you, for 6 bags of Celite will actually do the work of 7 bags of other diatomites.

And Celite is uniform. Every pound of it comes from Lompoc, California, the world's largest and purest diatomite deposit. Here, J-M technicians process and grade it so that no matter which convenient J-M warehouse you order from, the physical and chemical properties of each grade will never vary.

In addition, from Celite's full line of filter powders you can select the one grade that will give you the clarity you need at the highest flow rate.

So if filtration belongs in your processing operations, it will pay you to call in your local J-M Celite engineer. Backed by Johns-Manville's research facilities and years of practical diatomite experience, he can help you with your filtration problems. Call him today or write Johns-Manville, Box **14,** New York 16, New York. In Canada, write 565 Lakeshore Road East, Port Credit, Ontario.

*Celite is Johns-Manville's registered trade mark for its diatomaceous silica products.

Johns-Manville CELITE FILTER AIDS

Letters to the editor

DO OUR STUDENTS REALLY TRY?

In the November, 1956, issue [of *CEP*] the summary [by] L. L. Strauss regarding the shortage of technical students in college produced the same reaction in me that always occurs when I hear the same opinions offered. I was raised in the last generation, and under the British school system in the West Indies, and, after taking two years of Liberal Arts college, and then being out of school for nine years, I returned to take five years of chemical engineering in the U. S.

I believe the causes of our problem are much more basic than Mr. Strauss infers. The whole approach to education in this country seems to me to show that high school students, and even many college students feel that they go to school *to be taught*. Something is to be *done for them*, because it is their right.

Where I went to school we developed the concept that education was a privilege, and the student's responsibility; the teacher was an aid and a guide to the learning process. The continental type of college class, with no compulsory attendance at classes, tends to give freedom to the student who really wants to learn, and, at the same time tends to show up poor teachers; as, when few students show up for a class consistently it indicates that they feel they can do as well without the teacher's assistance as with it. I'm constantly told that classes in American colleges and high schools must be compulsory, and I can readily see why. Psychology and educational theories fill the student's mind with all kinds of excuses that he can offer if he fails: a poor teacher, a poor seat, too little time, a poor text, frustration at home, nosey parents or indifferent parents.

The only hopeful sign I see for the American is that the "do-it yourself" movement is competing with the "spectator" movement, preventing us from becoming a nation of nonparticipating spectators with so much money that we can afford to go to seed while someone else does everything for us. Education requires student participation. In fact it would be better if more courses had enough flexibility to allow the student to select his own texts, or other sources of information, and that tests were more objective, really testing the grasp of the subject rather than the memorization of a particular author's presentation.

With regard to the subject of teachers I would also offer an objection to the implication that inherently a part-time teacher is less qualified than a full-time one. I have done some part-time teaching but my devotion to that task was none the less than any of the full-time staff members, and this was reflected in the attitude of the students, who showed up 100% one day for a class when all classes had been excused, because they knew that I would not know of the dismissal of classes. (That was the greatest compliment I ever received.) I am in favor of increased salaries for teachers, but I do not believe increased salaries will necessarily produce better teachers. In fact, usually the poorest paying jobs attract only the most devoted people, hence, when salaries are increased to the place where they are competitive with industrial salaries, we must expect to attract the person more interested in money than in performance. The opportunity for slackers is greater in teaching than in industrial work because of the inherently greater freedom, with its corresponding responsibilities.

I agree that requirements ought to be stiffened for college entrance but I think we must start to instill in the American public the knowledge that accomplishment of true learning requires student dedication and a willingness to go farther than required reading.

Ralph Cushing

St. Louis, Missouri

A Weighty Subject

Re: page 58, November, 1956—photo of tower: 410,000 tons! at $1.00/lb. would cost $820,000,000. Also those cables would snap.

White Plains, New York *Anon.*

We will try to pound this fact into our proofreader.

Misquotation

In your section "About Our Authors" of the November issue of *CEP*, page 30, I note that I have been misquoted. I bring it to your attention only because the misquotation destroys the intended sense of my statement in my letter of October 26. All the processes we license are exclusively for achieving desired results, however, they are not the only processes for achieving those same results. That is why I said, "the processes we license are not exclusive for achieving the desired results, hence, my work involves evaluation of competitive processes . . . etc."

J. A. Samaniego

Emeryville, California

N.I.C.B. REPORT:

UNIONIZATION AMONG ENGINEERS

(*Continued from page 22*)

production workers unions (usually in special bargaining units, however), the big three for engineers being United Automobile Workers, United Steelworkers, and the International Union of Electrical Workers, all AFL-CIO.

CONTRACT PROVISIONS

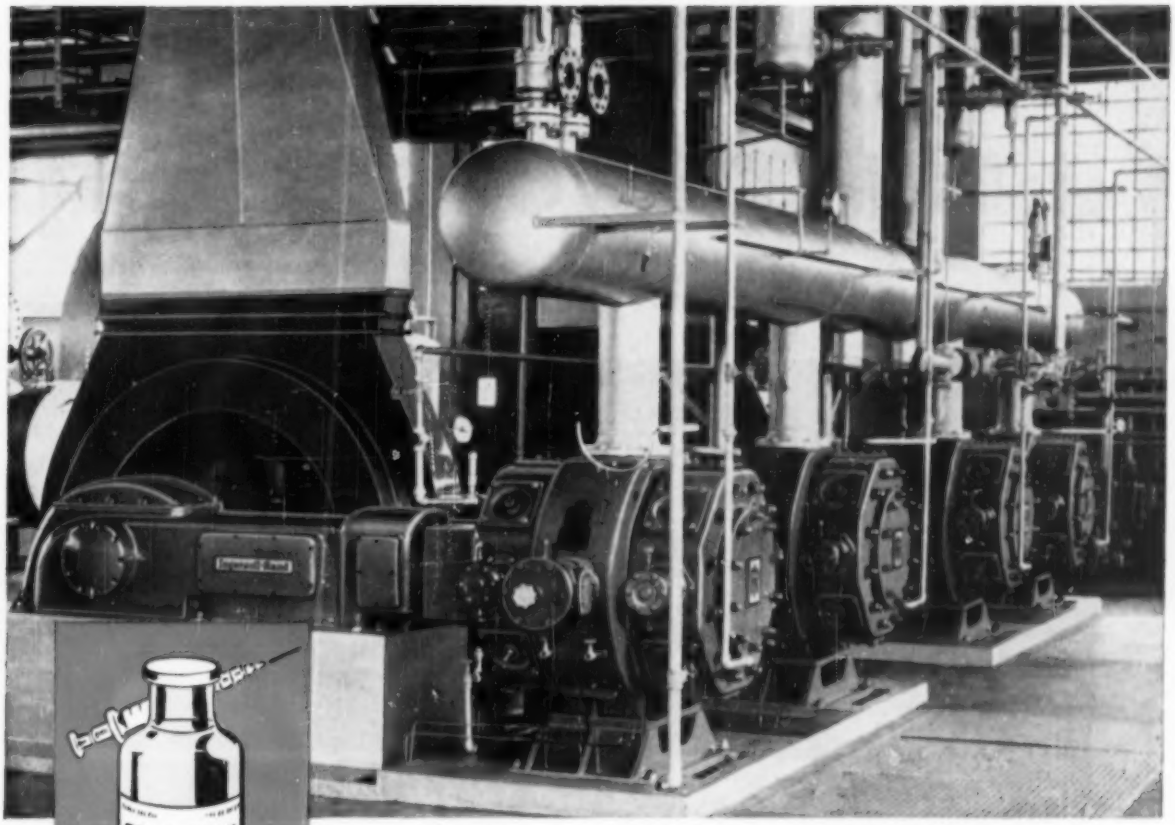
The provisions of most engineering union contracts have been compared and analyzed by NICB, throwing considerable light on inducements offered engineers to go into unions.

Provisions stressed in the contracts include: 1) salary classification providing about one-to-three differential between beginners and experienced engineers; 2) pay for *scheduled* overtime beyond forty hours, with the overtime pay cut-off point as high as $12,000 to $15,000/year; 3) merit rating provisions, with the union sitting-in on merit reviews; 4) away-from-home pay provisions, including family relocation allowances; 5) professional status provisions, which include employer payment of professional society dues, paid time-off to attend professional meetings, tuition refunds, educational and professional leaves of absence; 6) provisions that management will not use seniority as the *only* criterion for lay-off or recall, merit must always be a factor in some form; 7) patent agreements.

The reader will be interested in a detailed report by H. L. Rusch on a study of What Engineers Expect From Industry made by Opinion Research Corp., Princeton, N. J., which appears on page 50-J of this issue.

Conclusion

It is indeed noteworthy that an organization of the prestige and membership of NICB should choose this subject for one of its studies. It is also noteworthy that the study, as represented by the report, makes available such a compilation of the representations by the various groups involved, particularly EJC, through which the A.I.Ch.E. has expressed its views on the subject of professional status which arose through the original Dinsmore Committee activity, and the pioneer statement of professional standards which A.I.Ch.E. issued in 1955.



Two 400 hp PRE compressors furnish oil-free air for the E. R. Squibb & Co. penicillin plant in Santa Amaro, Sao Paulo, Brazil

Penicillin manufacture demands clean, oil-free air

Compressed air is the best medium for the agitation and oxidation of antibiotic fermenters in the manufacture of penicillin. However, conventional compressors allow some of the lubricating oil from the compressor cylinder to carry over in the air which would contaminate the finished drug and perhaps kill the precious organisms that are vital to the process.

The solution to this problem was simple enough . . . Ingersoll-Rand NL non-lubricated compressor cylinders were specified. These cylinders use special carbon wearing rings and piston rings that require no external lubrication. And the only special maintenance required is a yearly check of piston clearance to determine if new wearing rings are required.

This famous NL construction, an Ingersoll-Rand first, is the answer to many compression problems where oil may not be used, whether it be in drug, food, power or chemical plants. NL cylinders can be furnished on compressors from ½ to 1000 horsepower. For further information contact your local Ingersoll-Rand representative or write.

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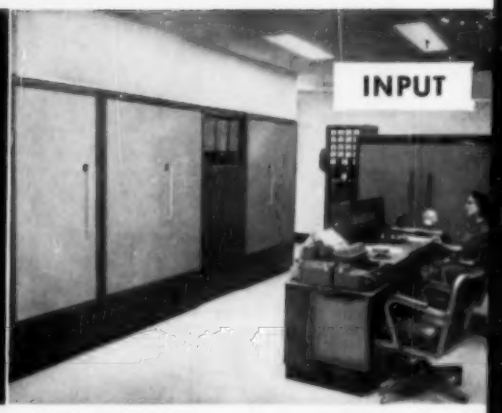
Electronic Route to

Super-Speed Computer Minimizes Heat Transfer Surface Requirements of Heat Exchangers . . .



Control section of Kellogg's computer

IN DESIGNING heat-pressure process equipment, the addition of a large magnetic drum digital computer to M. W. Kellogg's facilities enables the company's engineers to study variables and produce results with unprecedented thoroughness, accuracy, and speed. Human error is practically eliminated.

To Kellogg's customers in the petroleum and chemical industries, this new electronic aid means that Kellogg engineers can devote more time to basic design problems, and provide equipment with maximum operating efficiency, minimum maintenance costs, and the lowest possible initial investment.

In the case of heat exchangers, for example, design calculations require a trial and error solution. The time required to do this with hand calculations seldom permitted several design alternates. Thus the engineer never could be sure that the design selected was the true optimum. With high speed electronic computation, however, the greater number of alternates economically possible now brings the ultimate or near ultimate design to every Kellogg customer.

In one instance recently, involving 37 heat exchanger shells, the greater number of calculations achieved with the electronic computer resulted in reducing total heat transfer surface requirements by more than 15% from estimated values. Without the computer, the time required to obtain this value would have outweighed the saving many times, and would have been prohibitive.

Kellogg welcomes the opportunity to put its electronic computer and other engineering facilities to work for you. Arrangements to see the computer in operation in Kellogg's New York office can be made by contacting the company's Fabricated Products Division.

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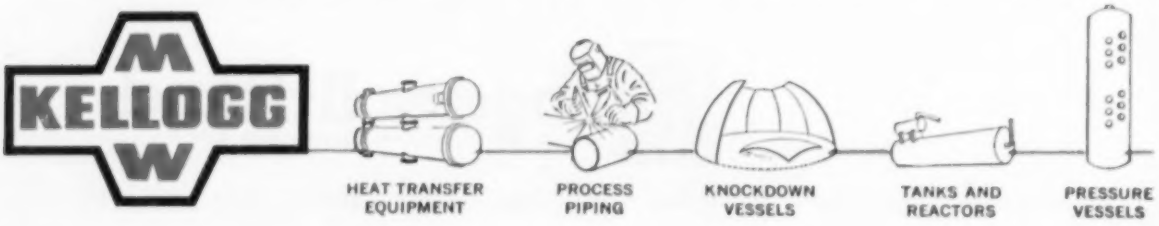
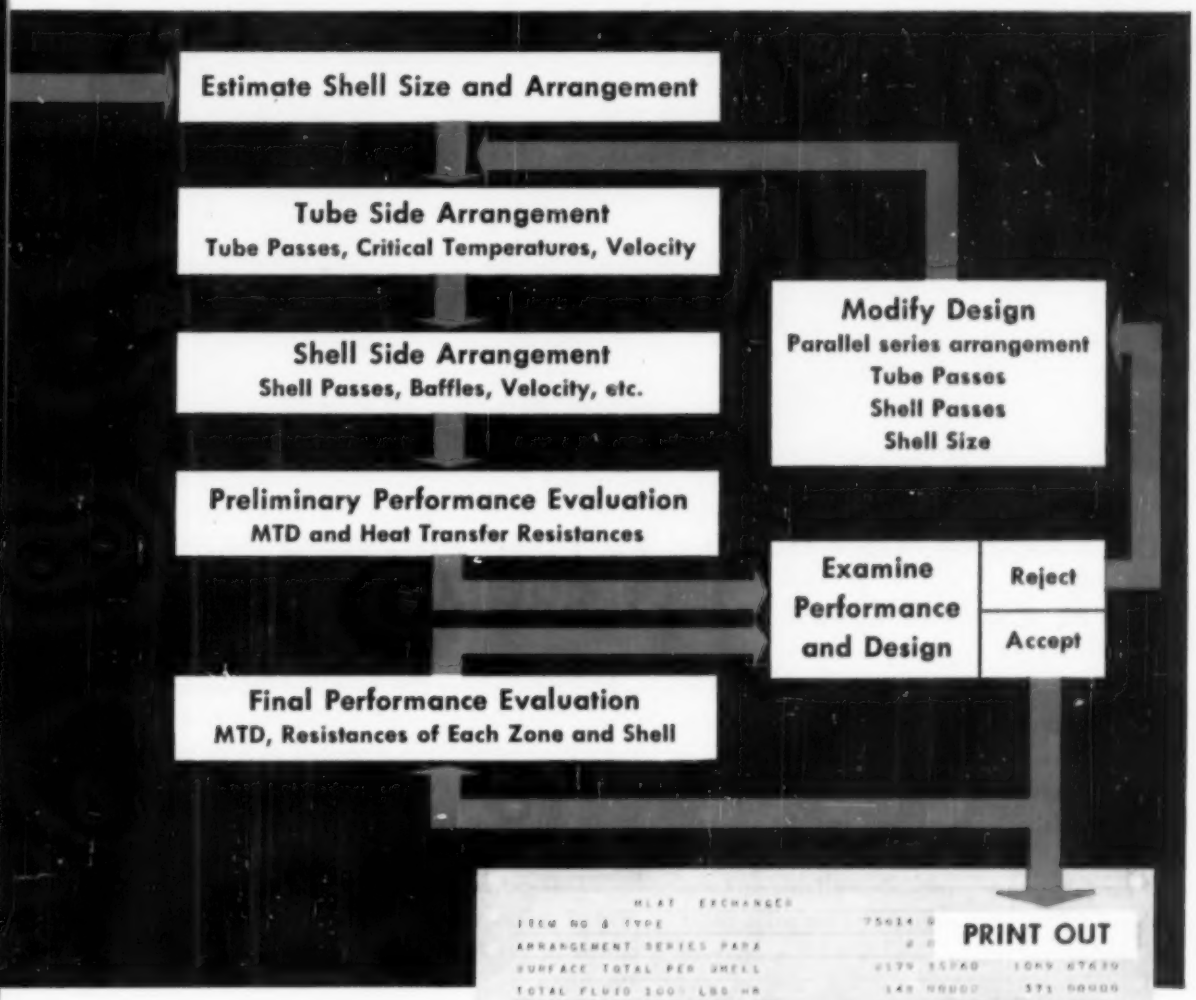


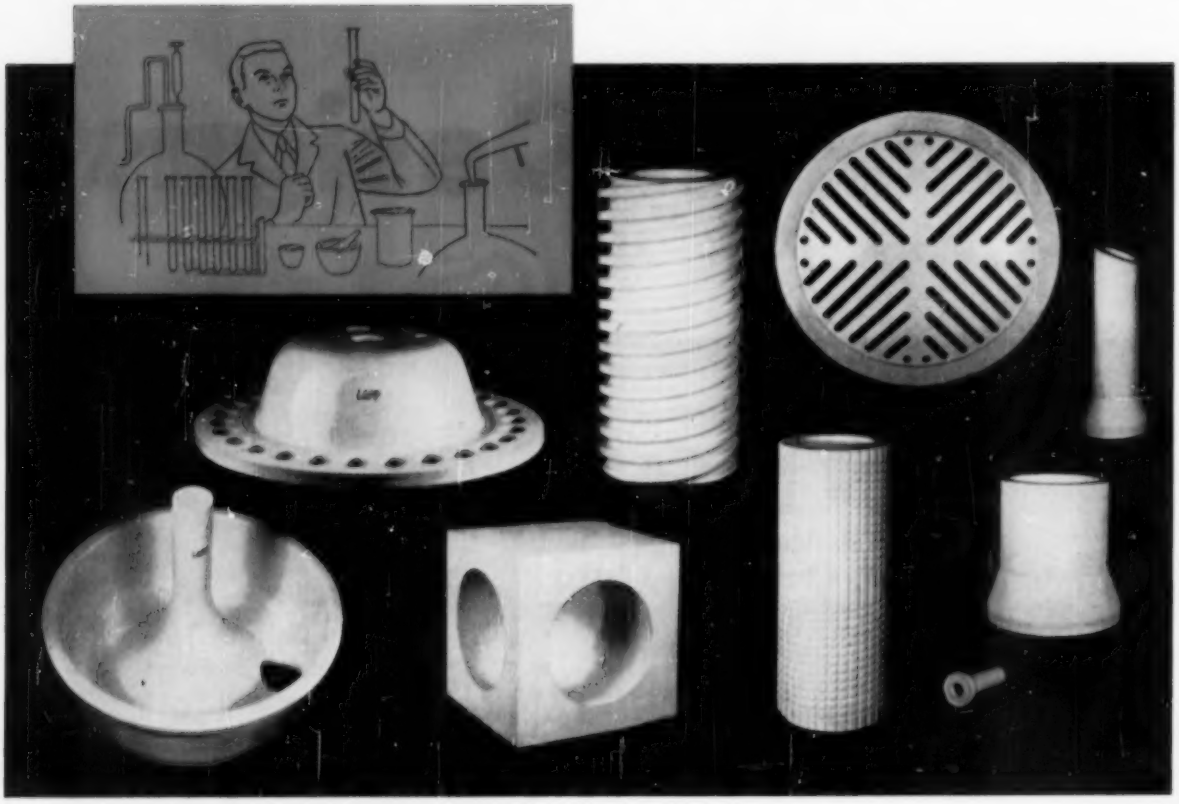
Optimum Designs



This liquid-liquid heat exchanger design flow sheet shows the route taken by Kellogg's electronic computer to obtain optimum design results. The boxes shown at right indicate the paths taken by the machine in arriving at the solution. Photograph at right is of a partial tabulation, showing how the computer presents results.

HEAT EXCHANGER

ITEM NO & TYPE	75634 B		
ARRANGEMENT SERIES PARA			
SURFACE TOTAL PER SHELL	6179	35760	10M9 67639
TOTAL FLUID 300 LBS HR	148	00000	571 00000
SP GRAVITY LIQUID		87670	87630
TEMP VISCOSITY F CS A	00130	05306	05830 01706
TEMP VISCOSITY F CS S	03300	01309	03300 01805
TEMPERATURE HOT	100	00000	350 00000
TEMPERATURE COLD	220	00000	086 00000
TUBE PASSES PER SHELL		00000	8 00000
PRESS DROP ALLOW PSI	00	00000	10 00000
PRESS DROP CALCD PSI	9	96000	11 80021
FOUL RESIST & TUBE DIAMTR		00004	1 00000
DUTY BU BTU HR & MTD BTO	25	50000	07 66713
TOTAL RESIST SERVICE CALCD		01434	01163
DESIGN PRESSURE PSI	150	00000	300 00000
TUBE NUMBER AND LENGTH FT	212	42078	40 00000
SHELL IDS DIAN BAFFLE PITCH		0000	0 01000



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WRITE *for bulletin describing the characteristics of Lapp Chemical Porcelain. Lapp Insulator Company, Inc., Process Equipment Division, 840 Wendell St., Le Roy, New York.*

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Now for the first time, there is available to industry a Super Classifier that provides ultra-sharp separations at high capacity, regardless of feed rate or size distribution in the feed—plus product recovery (yield) considerably higher than by any other means.

The Sharples customer demonstration plant is in all respects a full-scale commercial size classification plant capable of running continuously from 1,000 lbs. to 3,000 lbs. of product per hour. *Test results, therefore, are direct, require no extrapolation, and are precisely those obtainable from a Super Classifier of any capacity up to approx. 30,000 lbs. per hour.*

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About our authors

Creelman

Ackoff

Wallen

George Creelman, who rounded up *CEP*'s OPsearch articles, writes, "my own interest in OR began years ago as a chemical engineer, even before the name Operations Research was invented. The problems we worked on then were only a fragment of those concerning modern OR; many of the powerful tools of the present hadn't been invented." This initial interest arose while Creelman was working in Kellogg's patent department, where human relations and motivation were seen to be of equal importance with technology. From this he came to realize how dependent the development of today's complex systems is on the achievement of successful group creativity. Creelman is today president of his own OR consulting firm, relaxes with hi-fi and "gadgets."

Russell Ackoff is president of the Operations Research Society of America, professor of Engineering Administration and director of the Operations Research Group at Case Institute. Interested in research design, he is author of *The Design of Social Research* and co-author of *Methods of Inquiry*. Ackoff, like many OR people, took his original training in another field (architecture) but followed this with a Ph.D. in philosophy.

Dick Wallen, senior associate of Creelman Associates, is particularly interested in training people to work together in groups, serves in this connection on staffs of National Training Laboratories and Midwest Training Center in Human Relations. A psychologist, Wallen was for ten years on Western Reserve's teaching staff, has recently been teaching via television. He is author of a textbook in psychology published last spring.

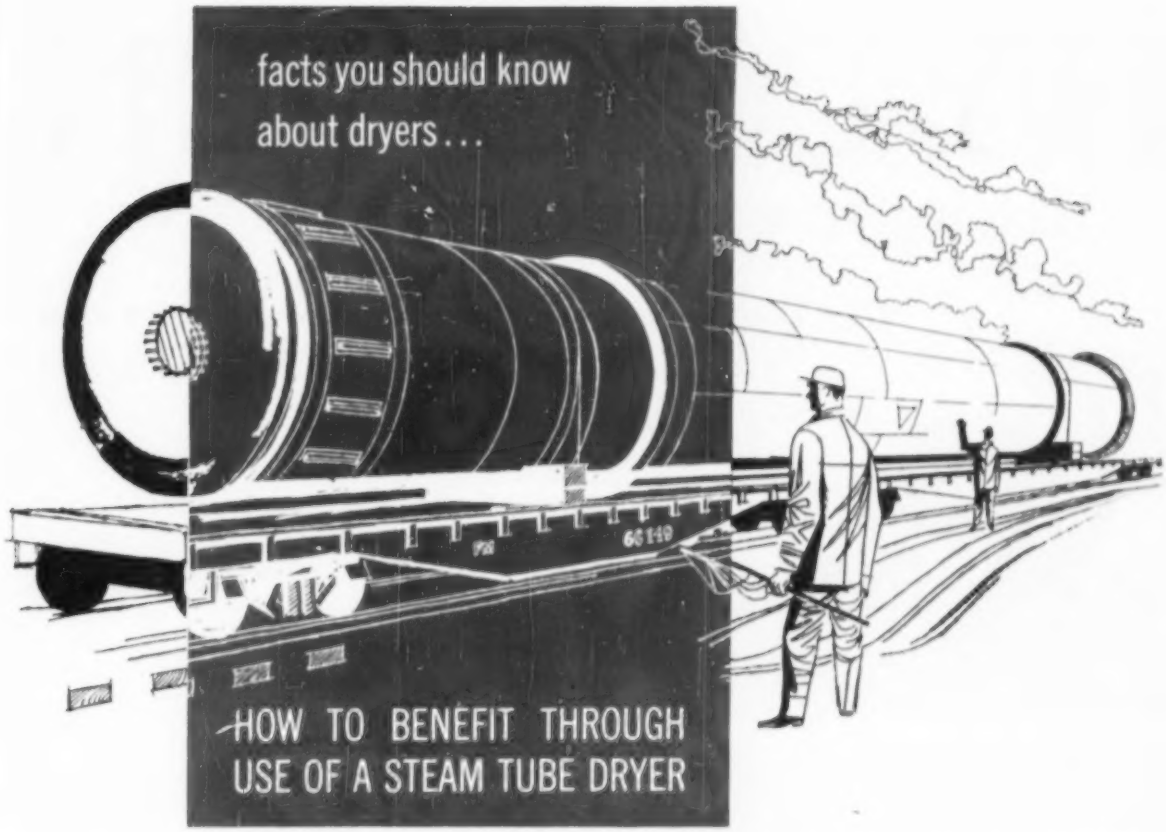
Tom Ware is known as an enthusiastic exponent of OR as a scientific management tool. Believing in what

(*Continued on page* 40)

Ware

Klingel

Hashbarger



For over 55 years, Louisville Dryers have been solving industry's drying problems and effecting marked economies. This experience can often be applied to provide unusual benefits in specific cases, possibly yours, for example . . .

Q. *Since avoiding dust loss and contamination by furnace gases indicates the choice of an indirect heat rotary dryer for my material, what type of indirect dryer would you recommend?*

A. Unless there are abnormal conditions, *we would recommend a steam tube dryer*, especially if the material is heat sensitive.

Q. What advantages does the steam tube dryer offer *in comparison with indirect fire types?*

A. There are many advantages. One is ease of operation and low maintenance costs due to the definite moderate temperature (established by steam pressure) imposed on both the material being dried and on the dryer itself. Another advantage is that there is no furnace refractory maintenance. Still another advantage is quick "warm up" and "cool off". In many cases where the drying operation is intermittent, there is no need to shut off the steam supply or stop rotation when the wet material feed is interrupted since steam is condensed in quantity only when wet material is fed.

Q. *Isn't steam supposed to be an expensive drying medium?*

A. That depends on how the steam is used. It is true that a low overall efficiency results (often as low as 25%) when steam is used to heat air for low temperature drying. However, the Louisville Steam Tube Dryer normally utilizes 85% or more of the available heat in the steam. By combining this with a reasonable minimum efficiency of 80% in modern small steam generators (and higher in large boiler plants), you get an overall efficiency close to 70%. This compares with indirect fire dryers which develop an efficiency seldom higher than 50% and generally less.

Q. *Does material insulate the tubes by sticking to them or by clogging the spaces between tubes?*

A. Very few materials have this tendency to any serious extent and most of these, when properly conditioned before feeding, handle without difficulty. For the balance, no dryer using heated surfaces for heating the material is a proper application.

Q. *How can I be sure a Steam Tube Dryer will handle and dry my material satisfactorily?*

A. The General American dryer pilot plant is at your service. No charge for routine tests and demonstrations. No obligation, either. Write for test date.

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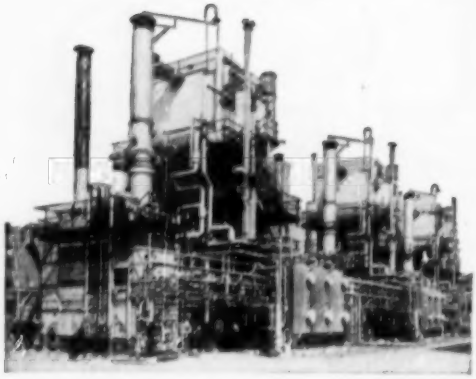

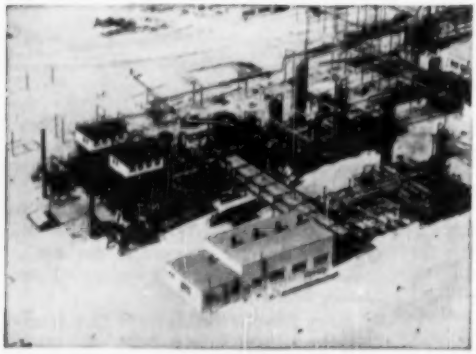

When you plan facilities for "tonnage hydrogen" for treatment of refinery feed stocks and hydrocarbon products, it will pay you to take advantage of Girdler experience.

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U.S.I. CHEMICAL NEWS

Jan. ★ A Series for Chemists and Executives of the Solvents and Chemical Consuming Industries ★ 1957

Nuclear Reactor Planned By U.S.I. and 9 Others For Industrial Research

A privately owned nuclear reactor for industrial research will be built and operated at Plainsboro, N. J. by a new company, Industrial Reactor Laboratories, Inc., formed by U.S.I. Division of National Distillers and 9 other companies.

U.S.I.'s participation in this new undertaking is one more step in its expanding research program. There are many possible avenues of research open. For example, radiation techniques provide new variations in the properties of polyethylene. The company is an important producer of polyethylene and plans to use the new reactor for the study of radiation techniques and effects on the resin.

Many chemical reactions may be energized or modified by the use of nuclear radiation.

MORE

Model of the Industrial Reactor Laboratories research reactor to be built by 10 participating companies, including U.S.I. The reactor is the dome-shaped structure while the building in the foreground will house individual laboratories of the participating companies.

Greenleaf to Handle Market Development of Zirconium And Titanium for U.S.I.

William C. Greenleaf has been named Manager of Metals Development for U.S.I. and will be responsible for market development and sales of zirconium and titanium sponge, to be produced from U.S.I.'s two new plants now being built in Ashtabula, Ohio.

A recognized authority in the field of zirconium and titanium, Mr. Greenleaf presented three papers during the 1955 Atomic Industrial Forum Zirconium Program, describing (1) melting of zirconium, (2) fabrication of zirconium, and (3) zirconium mill products and prices. He also conceived and developed processes now in general use for producing both wide-sheet and flat-bar titanium and zirconium by continuous strip-mill techniques.

Zirconium and Titanium Lick Roughest Corrosion Problems

Metals to be Available at Lower Cost in Future; Provide Long-Lived Materials of Construction; Complement Each Other on Corrosion Resistance

It is now practical to fabricate equipment which is *corrosion-resistant to almost every substance encountered in industry*, by using either zirconium or titanium metal. Alloys of either metal, or possibly both, may extend the range even further.

Steam jet made of zirconium, at left, gives trouble-free performance after a year in hydrochloric acid service. At right, throatpiece from steam jet, made of cast iron, looks like this after one week in hydrochloric acid service.

To date titanium has been used principally in aircraft construction, where its high strength-to-weight ratio offers great advantages. And zirconium has been developed primarily for atomic energy work as a strong and corrosion-resistant metal with desirable nuclear properties. The demand for titanium and zirconium created by these applications has greatly accelerated the production capacity and fabrication technology of these "new" materials of construction, making them available to the chemical industry in a short time and at a reasonable price.

Supply Increasing in 1957

Industrial applications of these metals have been hampered by two considerations: availability and price. Zirconium will shortly be produced at a rate sufficient to supply industrial needs, and titanium has been available to industry during the past two years. And it is expected that increased production of these metals during the next few years will result in significant price decreases.

MORE

Typical Corrosion Resistances* of Zirconium and Titanium

Corrosive Media	Metal Resistance	
	Zirconium	Titanium
Sulfuric Acid	excellent to good below 80%	good below 5%
Nitric Acid	excellent	excellent
Hydrochloric Acid	excellent	good below 10%
Phosphoric Acid	excellent to fair below 85%	poor
Chromic Acid	excellent	excellent to good
Aqua Regia	poor	excellent
Wet Chlorine Gas	poor	excellent
Chlorine Water	excellent	excellent
Sodium Hydroxide	good below 90%	good below 50%
Ferric Chloride	poor	excellent
Calcium Chloride	excellent	excellent
Cupric Chloride	poor	excellent
Sodium Chloride	excellent	excellent
Ammonium Chloride	excellent	excellent
Aluminum Chloride	excellent	excellent to fair

*Above data do not cover all conditions because of space limitations. Literature references may be obtained by writing the Editor, U.S.I. Chemical News, 99 Park Ave., N. Y. 16, N. Y.

Jan. ★ **U.S.I. CHEMICAL NEWS** ★ 1957

CONTINUED *Corrosion*

Twelve to thirteen thousand tons of titanium were available in 1956 and present construction schedules indicate that the figure will rise substantially in 1957. U.S.I.'s new plant alone will add 5,000 tons to the annual production capacity by the end of the year. Zirconium will be on the market in quantity by mid-1957. When its new plant at Ashtabula, Ohio gets under way, U.S.I. will be able to supply 500,000 pounds or more per year to commercial users in addition to its Atomic Energy Commission commitments of 1,000,000 pounds per year.

New Metals Economical

Chemical process equipment can now be fabricated from titanium for a little over twice the price of stainless steel, and it is expected that in the future titanium equipment will be only 50-75% higher than stainless. Commercial grade zirconium equipment will probably be priced only 75-100% higher than stainless when volume production is reached.

Several other factors combine to make zirconium and titanium economical as corrosion-resistant materials of construction. For many of the more difficult-to-handle chemicals, especially chlorides and oxidizing acids, equipment fabricated from these metals can have extremely long service life. Product contamination can be virtually eliminated in chemical and food handling processes.

Corrosion resistances of zirconium and titanium to typical chemicals are presented in the chart on page 1.

Methionine Increases Protein Utilization Of Dried Fish Meal

Supplementation of commercial fish meal with DL-methionine, an essential sulfur-containing amino acid, raises significantly the net protein utilization of the meal, according to a report recently published in England.

During the drying process, the action of heat in the presence of moisture is said to impair the protein quality of fish meal. Methionine becomes the chief limiting amino acid, and increasing the methionine content of the fish meal through supplementation restores most of the protein value of the meal.

CONTINUED *Reactor*

U.S.I. plans to look into new and more efficient processes for the production of a wide variety of chemicals through research at the proposed installation.

Participation in the project will also enable U.S.I. to make further studies on materials for nuclear reactors. The company is a major producer of metallic sodium, used as a heat transfer medium for certain types of reactors.

And zirconium will be produced by U.S.I. in the near future under a contract with the Atomic Energy Commission. Zirconium is a key structural material for atomic reactors and a raw material for the production of reactor fuel elements. The company is vitally interested in developing still other materials and chemicals used in the generation of atomic power.

Faye Named Manager of Sodium Product Sales

Martin Faye has been named Manager of Sodium Product Sales for U.S.I. and will be responsible for coordinating sales and sales promotional activities for metallic sodium, "U.S.I. Isosebacic" acid and related products.

Mr. Faye joined the U.S.I.-National Distillers organization in 1952 in the Market Research and Development Department, where he was responsible for commercial development of "U.S.I. Isosebacic" acid. "U.S.I. Isosebacic" is the registered trade mark for a mixture of 10-carbon dibasic acids produced synthetically for the first time by a U.S.I.-developed process. A 10,000,000 pound-per-year plant to produce this material is under construction at U.S.I.'s Tuscola, Illinois plant site, and is expected to be in operation by mid-1957.

TECHNICAL DEVELOPMENTS

Information about manufacturers of these items may be obtained by writing the Editor, U.S.I. Chemical News.

Polyethylene "pillows" to retard evaporation of liquids in open tanks and vessels are now being produced. They are air-filled, ⅝" by 1¼" by ½" in size. A 1½" layer is claimed adequate for solutions at any concentration. **No. 1190**

Monomethylol dimethyl hydantoin, now produced commercially, is offered as an almost odorless donor of formaldehyde and for reaction as a substituted hydantoin. Contains 19% combined formaldehyde capable of liberation. **No. 1191**

New alkaline scale and oxide remover for iron and steel is said to act electrolytically for rapid removal without chemical attack. Recommended for plating lines and automatic equipment involving alkaline solutions. **No. 1192**

A zirconium-copper alloy now available is reported to combine high electrical conductivity with good strength retention at elevated temperatures. Suggested for electrical motor commutators serving above 500°F where strength is needed. Conductivity is 95.8% of copper. **No.1193**

Fire protection for chemicals is discussed in a new 152-page book which can be purchased by those interested in the subject. Chemical hazards are analyzed, and methods of fire prevention and fire fighting are covered. **No. 1194**

A new cellulose derivative dissolves readily in cold water and is suggested for use as a thickener, emulsifier, adhesive and binder. The material is an ethyl-hydroxyethyl cellulose. Solutions are claimed to resist mold. **No. 1195**

A dye for photographic emulsions has just been synthesized which extends their sensitivity far into the infrared. Known as thiahexacarbocyanine, the dye has its absorption maximum at 1140 millimicrons. **No. 1196**

Titanium wire cloth is now on the market in sizes from 60 mesh to coarser grades. It is reported to be particularly suitable for filtering or screening highly corrosive materials. **No. 1197**

A new material for standardizing acids directly in one step is now available to laboratory workers. It is tris (hydroxymethyl)- amino-methane, reported to eliminate the usual acid vs. base, base vs. phthalate procedure. **No. 1198**

Glycerine, its commercial grades, specifications, test methods, shipping and storage requirements, is described in a 19-page booklet just issued. A 17-page booklet on properties and uses of glycerine is also available. **No. 1199**

PRODUCTS OF U.S.I.

INORGANIC CHEMICALS:

Sodium, Metallic: cast solid in tank cars, steel drums, pails; bricks in barrels, pails.
Chlorine: liquid, in tank cars.
Caustic Soda: 50% liquid, in tank cars.
Sodium Peroxide: dust-free granules, in drums.
Sulfuric Acid: all strengths, 60° Baumé to 40% Oleum. Also Electrolytic grade to Federal specifications. Tank cars or tank wagons.
Ammonia: Anhydrous, commercial and refrigeration. Tank cars or tank wagons. Also Nitrogen Fertilizer Solutions.

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Intermediates and Fine Chemicals: Acetoacetarylides, Ethyl Acetoacetate, Ethyl Benzoylacetate, Ethyl Chloroformate, Ethylene, Ethyl Sodium Oxalacetate, Sodium Ethylate solution, Urethan USP (Ethyl Carbamate).

Animal Feed Products: Calcium Pantothenate, Choline Chloride Products, Curbay B-G® 80, Special Liquid Curbay®, DL-Methionine, Niacin USP, Riboflavin Concentrates, Vitamin B_{12} and Antibiotic Feed Supplements, Vacatone® 40, Vitamin A, D_3 and K_3 Products, Antioxidant (BHT) Products.

Pharmaceutical Products: DL-Methionine, N-Acetyl-DL-Methionine, Riboflavin USP, Urethan USP, Intermediates.

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Marginal notes

Fluidization. Donald F. Othmer, Editor.

Reinhold Publishing Company, New York (1956), 231 p., $7.00.

Reviewed by Max Leva, Consulting Chemical Engineer, Pittsburgh, Pennsylvania.

The book consists essentially of two parts: the first part comprises one third of the volume, discusses certain fundamentals of fluidization; the remaining two thirds is primarily a collection of papers that were presented at the February 2, 1955 symposium at Brooklyn Polytechnic Institute, to celebrate the centennial of that school.

The avowed purpose of the book is to give an integrated description of fluidization as practiced in a number of modern processes. This has been largely achieved.

In the introductory chapter, aspects pertaining to the dynamics of fluidized systems are given, in particular quantitative working correlations for pressure drop, prediction of incipient fluidization, and solids elutriation.

In the treatment on heat transfer a distinction is made between various systems, that is, systems pertaining to heat exchange between bed and exterior walls, as well as systems involving internally placed heat transfer surfaces. Also presented are developments in the matter of particle-fluid heat exchange. Significant contributions from the literature are reported and individual correlations cited.

The following chapters are primarily descriptive in nature, although much useful information, not available in this form elsewhere, is brought together here. The chapter termed *Graphical Analysis* describes flows and solids densities.

Next follow two chapters elaborating on the history and background of fluidization and the operating characteristics and engineering problems involved. The remainder of the book deals with more specific subjects, such as processes, design, control elements, and applications. Specifically the chapters inform on fluid coking, and moving bed technology, details of cracking plants, and a discussion of fluidization in relation to some typical inorganic ore roasting and other processes.

As pointed out in the preface of the book this is the first coordinated effort to describe fluidization as applied to engineering practice and as such it should be of much interest to those working in the field or in related regions.

High Temperature Technology, J. E. Campbell, Editor.

John Wiley & Sons, Inc., New York (1956), 526 p., $15.00.

Reviewed by Nevin K. Hiester, Manager, Chemical Engineering Section, Stanford Research Institute, Menlo Park, California.

This book is a direct result of a symposium titled "High-Temperature Materials, Methods and Measurements" held at a 1951 meeting of the Electrochemical Society in Washington, D. C. It consists of a number of contributions summarizing recent developments in high-temperature technology. These were chosen by J. E. Campbell, the editor, to provide the reader with a knowledge of established techniques and materials in this field.

As would be expected, the book's major sections are: Materials, Methods, and Measurements. The first is a group of articles covering certain elements and their high-temperature binary compounds. Although they may not be complete, they serve as reference material since each chapter provides a good bibliography.

In the Methods section, use of resistance and induction-heated furnaces, arc furnaces, and other means of achieving high temperatures are described in some detail. However, this section tends to stick to specific equipment rather than to discuss broadly the advantages and disadvantages of various ways of achieving high temperatures. It should be pointed out that combustion processes for this purpose are not reviewed.

The final section, that on Measurements, discusses methods of determining temperature, and mechanical and physical property measurements.

As might be expected in a book of this type, it is somewhat uneven in quality due to the use of many contributors. Nevertheless, the book is good and is an important basic reference for those interested in high-temperature technology.

The Mathematics of Physics and Chemistry, 2 ed., Henry Margenau and George M. Murphy.

D. Van Nostrand Company, Inc., Princeton, New Jersey (1956), 604 p., $7.95.

Reviewed by Raymond W. Southworth, Associate Professor, Department of Chemical Engineering, Yale University, New Haven, Connecticut.

The first edition of this textbook ran through fifteen printings, an indication of its popularity not only with physicists and chemists but also with mathematicians, chemical engineers, and others. It was intended to be used as a first-year graduate text or possibly in connection with senior courses in theoretical physics or chemistry. In the second edition the general plan of the book has not been changed; instead there have been numerous small additions and attempts to improve various sections. Probably the major change is inclusion of material on complex integration and on Laplace and Fourier transforms. The discussion of the use of the Laplace transform is restricted to ordinary differential equations, however.

The aim of the textbook is to provide the mathematical tools which are needed by students of theoretical physics and chemistry and to do this concisely but without sacrificing important details or proofs. Topics have been selected which the authors believed to be of general interest.

Partial differentiation, especially as applied in thermodynamcis, is treated in the first chapter. This is followed by sections on ordinary differential equations, including series integrations, and on special functions. Chapters on vector analysis and coordinate systems include also some material on tensors. Much of the remainder of the book is devoted to topics which are of particular interest in chemistry and physics.

Numerical methods and matrices are discussed at length, and with the present rapid development of high-speed computers, these sections will undoubtedly be of interest.

Books received

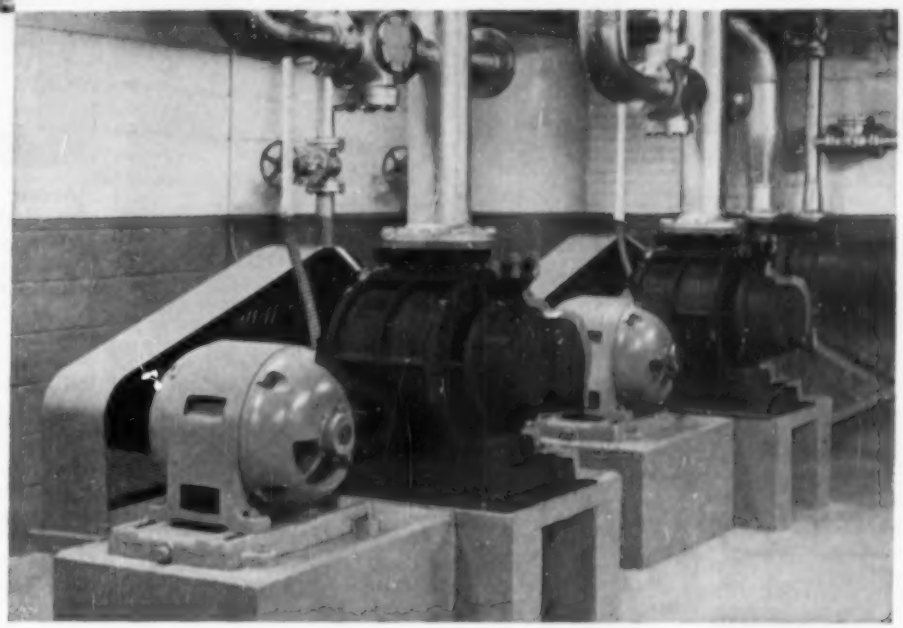
Our Smallest Servants, The Story of Fermentation. Chas. Pfizer & Co., Inc., Brooklyn, N. Y. (1955), 32 p.

Basic Mathematics for Science and Engineering. P. G. Andres, H. J. Miser, and Haim Reingold. John Wiley & Sons, Inc., New York (1955), 846 p., $6.75.

Handbook of Radioisotope Applications. Nucleonics, New York, 144 p., $1.00.

Divided into six parts, this handbook covers Radiation Sources; Industrial Applications; Food Sterilization; Chemical Uses; Biology, Medicine, Agriculture; and Geology, Metals.

For R. J. Reynolds Tobacco Company



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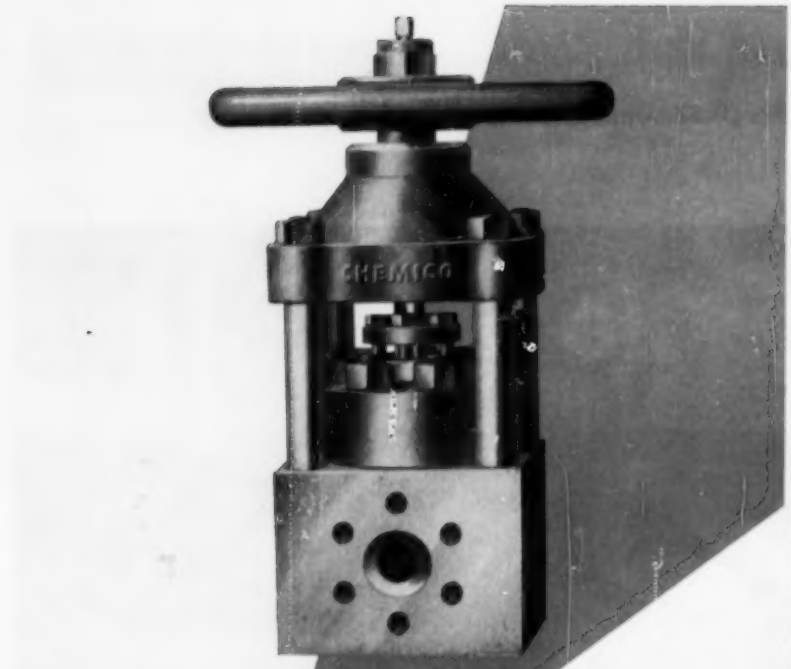

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About our authors

(*Continued from page 32*)

he advocates, he recently decided to re-examine IM&CC's chemical laboratory at the phosphate ore minesite, Bartow, Florida. This included his study, using a pedometer, of the amount of walking between benches the control analysts found it necessary to do. To his surprise, his calculations showed some technicians in the course of a year walking over a thousand miles. He is said to have shortly arranged for revision of the lab layout!

Arthur Klingel started out as a mechanical engineer, took OR graduate work at Case, is now supervisor of OR Research Section of Operations Staff, Manufacturing Dept., Standard Oil (Ohio). **Claude Cornett** also started in M.E., trained in statistics, is currently operations analyst in Ohio's OR Research Section.

After several years in production in Monsanto's domestic plants and four years in foreign manufacturing development, **Harlan Hashbarger** organized and headed a Central Production Planning & Control Group in the Organic Chemicals Division. **Norris Sample,** in this Group, has been conducting studies on manufacturing costs, production scheduling, and evaluation of manufacturing performance.

A. F. Shorkey is general superintendent of Alkali Products in Dow's Texas Division, became interested in statistics and statistical methods and their application to chemical production problems several years ago, feels OR was a natural outgrowth. **Joseph Rio** joined Dow four years ago as a statistical engineer with the job of introducing and disseminating statistical techniques and applications in the Inorganic Production Department.

J. B. Gray is a specialist in "how materials behave in pipelines, vessels, process equipment in general . . ." A fluid dynamics research engineer in DuPont's Engineering Research Laboratory at Wilmington, Gray tells *CEP* that *mixing*—the subject of his comprehensive report in this issue—is just part of his interests; these include *everything* that takes place in addition

(*Continued on page 44*)

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2. *Engineers Joint Council*
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March 11-15, 1957

Sponsored by the American Institute of Chemical Engineers with the cooperation of the American Society of Civil Engineers, the American Institute of Mining, Metallurgical and Petroleum Engineers, the American Society of Mechanical Engineers and the American Institute of Electrical Engineers.

See the latest equipment, materials, and processes relating to the non-military uses of atomic energy in its various forms on display—many of them for the first time. Virtually all major suppliers or services to the nuclear energy field—from mining equipment and supplies to power distribution, electronics, chemical, metallurgical, mechanical, and many others—will display. Foreign industry and government will also be represented.

In addition to the thousands who registered for the technical sessions at the 1955 Nuclear Congress, over 15,000 registered to view the 165 exhibits—engineers, scientists, executives from industry, purchasing officials, press, educators, technical students, etc. Attendance at the 1957 Congress is expected to be even bigger.

Headquarters for exhibit information is:

International Atomic Exposition
117 South 17th Street
Philadelphia 3, Pennsylvania

5TH ATOMIC ENERGY IN INDUSTRY CONFERENCE
March 14-15, 1957

Sponsored and conducted by the National Industrial Conference Board (460 Park Ave., N.Y. 22)

Reports on current and future economic effects of atomic energy and the way experienced companies are dealing with managerial problems arising from the generation of nuclear power and use of atomic by-products in research and production. The 14 sessions cover such topics as:

- *New markets for new metals and how to realize them*
- *Better product development through radioisotopes, radiation chemistry*
- *Safety, health, insurance, legislation*
- *Status of foreign and domestic atomic energy developments*

5TH HOT LABORATORIES AND EQUIPMENT CONFERENCE
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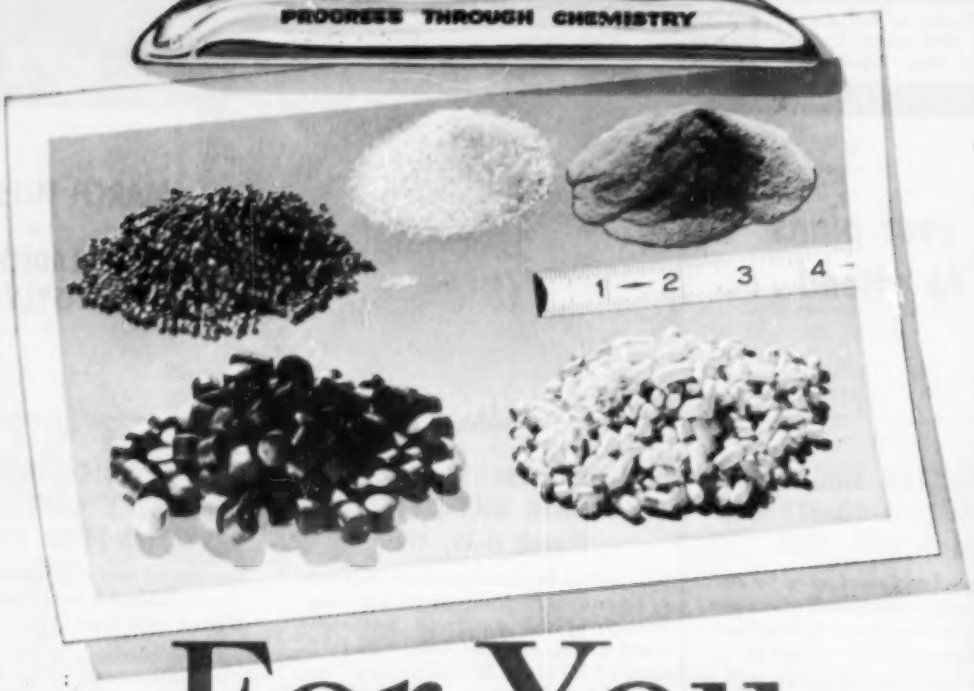

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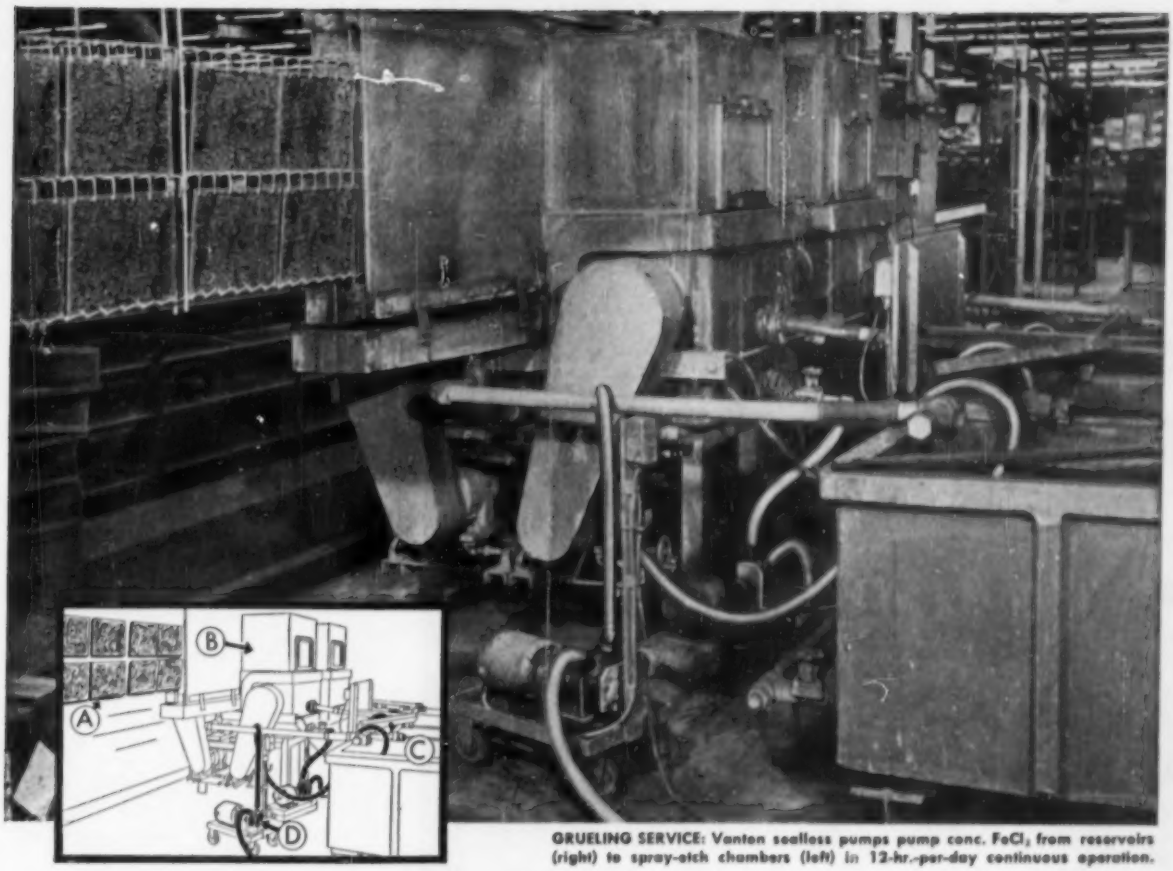

GRUELING SERVICE: Vanton sealless pumps pump conc. $FeCl_3$ from reservoirs (right) to spray-etch chambers (left) in 12-hr.-per-day continuous operation.

at WESTINGHOUSE's TV-Radio plant in Metuchen, N. J.

3 Vanton Sealless Pumps minimize maintenance problems in pumping ferric chloride for printed-circuit etching

PRINTED-CIRCUIT PROCESS — Copper foil laminated to baseboard has circuit diagram silk-screened with acid-resistant ink (A). Conveyed into etching equipment (B), excess copper foil not covered by resist ink is etched away by warm conc. $FeCl_3$. Later, vapor degreaser removes acid-resistant ink, exposing remaining copper circuit.

PUMPING PROBLEM — $FeCl_3$ is pumped continuously from reservoirs (C) (overflow return), to provide fresh liquor for spray-etch chambers. Before Vanton came on job, high corrosiveness of $FeCl_3$ and abrasiveness of crystals caused much trouble with conventional pumps. Leakage at packing caused crystallization, with abrasion and scoring of pumpshafts, and expense and nuisance of increased maintenance.

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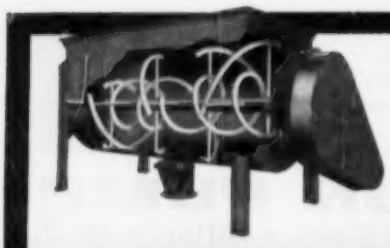
Whether you are mixing granular or pulverized, wet or dry materials, Readco's counterflow action spiral ribbon mixers will provide a thorough mix in less time and without material build-up at the bowl ends. These sturdy mixers are built for continuous or batch processing. They can be supplied for pressure of vacuum service, with or without temperature controlling jackets and in working capacities from 1 to 500 cubic feet. Readco also manufactures a complete line of double arm mixers, including laboratory and pilot plant models, vertical mixers and materials handling equipment. Modern laboratory facilities are available to assist you in determining the proper equipment to suit your needs. Write for complete details.



BAKERY-CHEMICAL DIVISION
YORK, PENNSYLVANIA

READ STANDARD
CORPORATION

About our authors

(*Continued from page 40*)

to the transfer of mass. For example, his studies go into reaction kinetics, heat transfer, etc., as well. "Once sensitized to the mechanism involved," revealed Gray, "I have learned a great deal by observing the practical, often intuitive, solutions to mixing problems worked out in the kitchen by the housewife. I can thus give additional credit to Mrs. Gray for being my major source of inspiration."

Paul Stewart, trained as a chemical engineer, is today a professor of M.E. at the University of California. Organizer of the only West Coast industry-sponsored school for teachers, he has authored papers on subjects as varied as unconventional applications of rocket motors and A.I.Ch.E. salaries. **Ernest Starkman** has alternated between teaching engineering at U. of C. and working as a research engineer with Shell Development; now he does both (the latter as a consultant).

Another whose career shows repetitive patterns is **Ralph Peak** (*cost of ion exchange*). First it was army, then university and industry. Then it was once again army, followed by graduate school, and back to industry. "From these associations I have acquired some experience in operational and management problems . . ." understates Peak. **M. M. David,** of the staff of the University of Washington, is distinguished, among other reasons, for having been a Fulbright fellow in the Indian Institute of Science (terms traveling an extracurricular interest).

Professional opinion researcher **Hugh Rusch** travels 50,000 miles each year "just to talk to Public Opinion Index clients about employee, public, and financial relations problems, and the important trends in these fields. The Index is conducted by Opinion Research Corp., one of the largest market and attitude research firms serving about 100 companies. **Joseph Goecke,** as research director of the Index, commented that the engineers reported on in *CEP's* article proved to be highly articulate, demonstrating considerable capacity for self-expression, in contrast to the common view of the engineer's skill in the humanistic arts.

David

Rusch

Goecke

Another client benefits from a Badger "Precious Plus"

An Achievement of Creative Engineering:

STYRENE FROM GASOLINE!

Sketch shows Cosden Petroleum's new ultra-fractionation and styrene manufacturing plant as it will appear when completed in early 1957. The four columns — each almost 200 feet high —will be among the tallest ever erected!

The plant that "couldn't be built" now under construction

At Cosden's Big Spring, Texas, refinery, Badger is erecting the first plant ever designed for the recovery of ethyl benzene by distillation. The process *first* became commercially practical when Badger Engineers developed Ultra-fractionation.

Now, instead of marketing catalytic reformer effluents as mixed solvents, this new distillation process will make it possible for the client to produce a pure product with a far higher profit margin.

This achievement in *Creative Engineering**, like all intangibles, can never be shown on the blueprints. Yet it is the "Precious Plus" in Badger's performance that is making Cosden's plant possible!

Other leading companies, too, find Badger's *plus* in performance of precious advantage — whether their need is design, engineering or construction. How else explain the unusual growth Badger is enjoying?

+ You need new "yardsticks" to measure the plus performance of Badger. For the abilities of this dynamic organization go far beyond what can be shown on blueprints—and it's such intangibles that add up to better processes and plants, faster and at lower cost.

Creative engineering . . . whether your process problem is common or complex, Badger engineers solve it with fresh thinking that frequently produces new efficiencies, unexpected savings.

Broad experience . . . Badger Engineers are more than competent—most staff members are recognized authorities in their fields.

Key Man operation . . . the Badger man who submits your proposal is always a principal—always the Key Man responsible for the execution of your job. Clients say, "This is the Badger difference that makes the difference."

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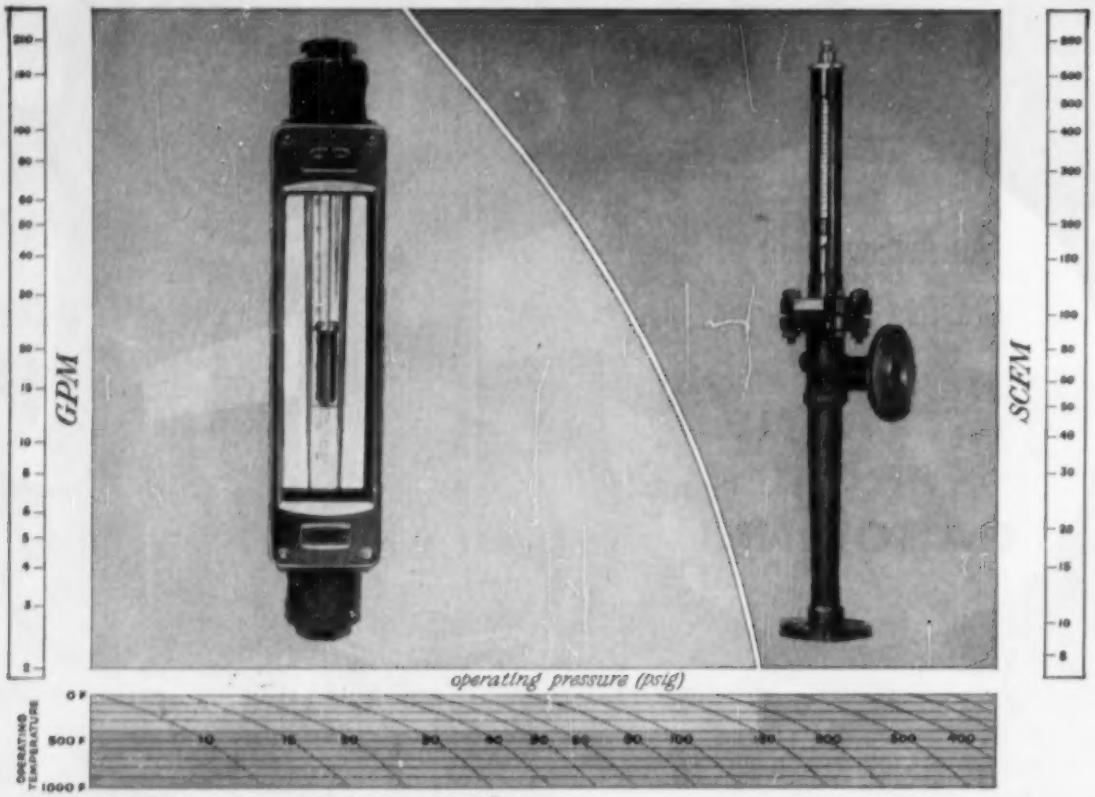
ENGINEERS CONTRACTORS DESIGNERS MANUFACTURERS



For all flow measuring problems...

F & P HAS THE ANSWER

Corrosive fluids or gases, corrosive atmospheres, high temperatures and high pressures are common flow measuring problems in the chemical industry . . . and they're being solved every day with Fischer & Porter flowmeters.

Two of the most popular types of F&P flowmeters are the 1700 Series Flowrator meter and the all-metal Fig. 52 armored Flowrator meter. These versatile meters give you a predictable calibration performance in all ranges doing away with the necessity of individual calibration. You can get maximum corrosion resistance because both meters are available in many different materials.

Here are just a few of the features of the 1700 Series flowmeters that make them especially adaptable to the chemical industry:

Stainless steel enclosure standard Eliminates costly maintenance because corrosive atmospheres are no problem.

Three designs in one basic instrument Side plate construction gives extra rigidity and prevents operating stresses and strains from being transmitted to the tube . . . standard enclosure gives extra protection against accidental tube breakage . . . pressure enclosure gives maximum protection.

End fittings rotate 360° Simplifies piping.

Built-in panel mounting fittings Longer bolts are all that is needed for front or rear panel mounting.

Controlled outside tube diameter Permits the use of *molded* teflon liner and pre-cut packing rings interchangeable within meter size.

The Fig. 52 armored Flowrator meter is another favorite of industry. Here's why:

Cold-formed metering tubes Unique cold forming of precision-bore metal metering tubes eliminates price differential between glass tube flowmeters and all-metal flowmeters . . . assures complete interchangeability of metering tubes.

150 lb. and 300 lb. flanges standard Eliminates any problem in the matching of flanges.

Only one moving part Minimizes maintenance and pressure drop.

This is only part of the story on what F&P flowmeters can do for your process. To get all the details on 1700 Series and Fig. 52 Flowrator meters, write to Fischer & Porter Co., 1116 County Line Road, Hatboro, Penna.

Catalogs on other F&P flowmeters

10-A-10—Introduction to F&P Flowrator meters
10-A-43—High capacity Flowrator meters
10-A-93—Selection Guide for Flowrator meters

FP FISCHER & PORTER CO. Hatboro, Pa.

COMPLETE PROCESS INSTRUMENTATION

LA 11448

AN ADAMS *Report*

• Filtration the Answer to High Costs of Industrial and Process Water

Part 1

The continued expansion of our free economy is forcing management and design engineers to face the problem of *water*. Water is as essential to industrial development as it is to human life.

Municipal Supplies Limited

More and more we read stories in the daily papers of various cities which have had to apply restrictions on water consumption. While sprinkling bans may ruin your lawn this year, it is an omen of a possible water shortage in the future.

Natural Resources Restricted

The use of natural water resources . . . lakes and rivers . . . is being restricted by pollution. For example, the entire water of one of the major eastern rivers is reused seven times while moving one mile down stream. To make use of this water for industrial purposes involves an extensive treatment system . . . resulting in a high initial capital expenditure.

Water the Life Blood of Industry

This is not a patent cliche! It is a basic fact. Years ago water's primary importance to industry was as a means of transportation. Today water is essential to industrial survival. As with any commodity, as the supply decreases with respect to demand, the price per unit increases.

The cost of industrial and process water has risen rapidly during the past 10 years . . . will rise even further and more rapidly during the coming 10 years.

Methods of Solving Problem

More and more firms consider the problem of water shortage when planning the location of new plants. Plant sites are chosen near natural water resources. When the source is a river or lake, their planning often includes waste water disposal . . . a factor that did not exist some years ago.

River and lake water, particularly during rainy season run-offs, require water treatment of some sort. The higher the quality of the water needed by the plant, the more expensive the water treatment . . . but in the long run it pays for itself.

Filtration of the raw water with an Adams AWF Automatic Filter may eliminate the need for a pre-treatment settling basin. If water softening equipment is used, the AWF may also help reduce the cost of this equipment by the removal of solids from the water to be softened.

Filtration After Treatment

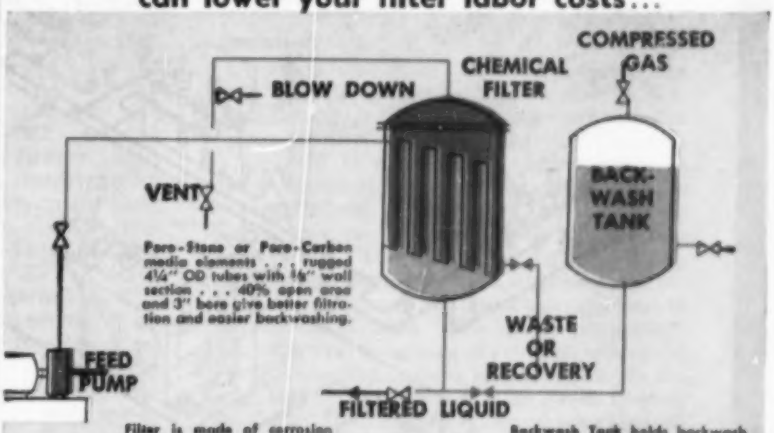
Where the polish of the industrial or process water is a critical factor, it very often pays to install a filter after the softening equipment. In this application the filter acts to remove the precipitated salts. These salts cause trouble by collecting in low spots, or reacting chemically when introduced into process solution. This phase of keeping your industrial water costs down will be covered in the next *Adams Report*. Watch for it.

New Bulletin Available

Bulletin 909, on the Adams AWF Automatic Filter is available upon request from the R. P. Adams Company, Inc., 540 East Park Drive, Buffalo 17, New York.

ADAMS BACKWASH DESIGN

can lower your filter labor costs...


COMPRESSED GAS
CHEMICAL FILTER
BLOW DOWN
VENT
BACK-WASH TANK
Para-Stone or Para-Carbon media elements . . . rugged 4¼" OD tubes with ⅛" wall section . . . 40% open area and 3" bore give better filtration and easier backwashing.
WASTE OR RECOVERY
FEED PUMP
FILTERED LIQUID
Filter is made of corrosion resistant alloys to meet process requirements. Note: Complete drainage from shell of filter cake after backwashing is obtained by sloping tube sheet.
Backwash Tank holds backwash liquid under head of compressed gas. Backwash liquid is forced back through filter in reverse flow at high velocities to clean filter in less than ½ minute. Note: no disassembly for cleaning.

TYPICAL BACKWASH FILTER CLEANING CYCLE

There are numerous filters which will meet the needs of your particular process. Your problem has become . . . "Which one shall I buy?"

Doubtlessly, there are other units which will produce as clear an effluent as the Adams filters. So the choice would seem to narrow down to initial investment. Here you will find Adams filters competitive in price.

What about operating and maintenance costs? That's where the Adams filter can save you money!

You clean your Adams filter by operating a few valves . . . no time consuming and often dangerous manual disassembly and cleaning necessary. Your filter is off-stream for as little as two minutes and seldom over 15. The liquid required for cleaning is only a small fraction of that needed by other filters using the reverse flow technique. And what's more, you get thorough cleaning. The Backwash liquid is easily recovered if necessary.

R. P. ADAMS CO., INC.
240 E. PARK DRIVE
BUFFALO 17, N. Y.

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R. P. ADAMS COMPANY, INC.
240 East Park Drive
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Gentlemen:

We have a problem in chemical filtration. Please send us your Bulletin 451.

Name.....Title.....

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City.....State.....

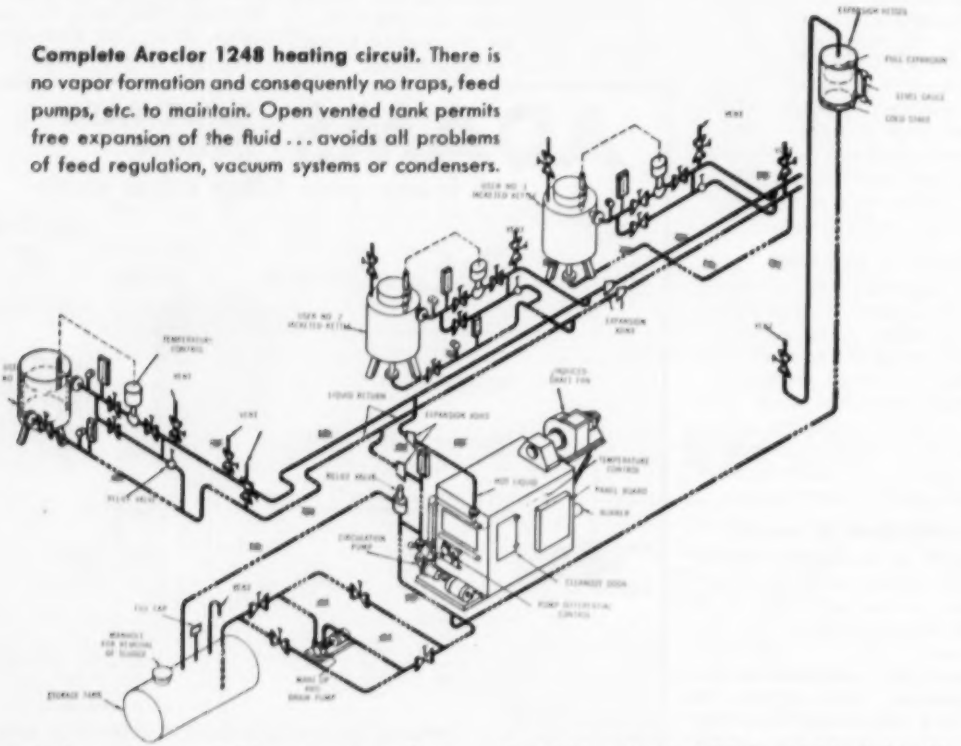
Now . . . **NON-PRESSURIZED** liquid-phase heat systems that operate up to **600°F.**

AROCLOR 1248

Operates at atmospheric pressure...cuts installation and maintenance costs of expensive pressurized systems.

Fluid is fire-resistant...increases safety by eliminating direct-firing, or heat transfer with flammable fluids.

Complete Aroclor 1248 heating circuit. There is no vapor formation and consequently no traps, feed pumps, etc. to maintain. Open vented tank permits free expansion of the fluid . . . avoids all problems of feed regulation, vacuum systems or condensers.



The Equipment . . . capacities can range from small portable units—usually electrically heated—to large gas- or oil-fired units generating from 250,000 to over 10,000,000 B.T.U.'s per hour. Circuits are closed, forced-circulation. Compact design saves space, minimizes installation and maintenance costs.

The Fluid . . . Aroclor 1248 is a highly stable chlorinated polyphenyl; does not support combustion up to its boiling range 652° to 725° F.; has autogenous ignition temperature of extremely high 1299° F.; is non-corrosive. Aroclor 1248 operates in most systems four to seven years without replacement.

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Write to us on your company letterhead. We will send you technical information about Aroclor 1248 and/or the names of Aroclor 1248 heat-transfer system manufacturers and designers. Organic Chemicals Division, MONSANTO CHEMICAL COMPANY, Dept. IF-2, St. Louis 1, Missouri.

AROCLOR, Reg. U. S. Pat. Off.

The chemical industry, in preparing for record plant expansion in 1957 and continued huge growth over the following four or five years, is faced with an increasing number of problems both within the industry and from world events which also affect other industries.

The Suez crisis, for example, has had repercussions that were not immediately realized. The cutting down in the supplies of Middle East oil has directly affected British and European chemical producers, but the oil situation will not in itself have very much effect on American chemical producers.

However, as a result of the closing of the canal, the Federal Government is pushing a 29 million ton increase in oil tanker capacity by 1961 from the present capacity of 43 million tons, an increase of nearly 70%. As a start, 27 new tankers will be built at a cost of more than $300 million. This will obviously further tighten the already tight situation in steel sheets and plates needed for chemical equipment and will likely also increase costs.

President C. L. Huston of Lukens Steel Corp., which specializes in steel plates, recently stated that 1957 will be an even tighter year for plate than 1956 and that he expected this situation to continue for about five years. He added that the petroleum industry, a major user of plate, is planning to spend around $33 billion over the next five years. The five year chemical expansion program will also take large amounts of plate. Eugene Grace, president of Bethlehem Steel Corp., backs Mr. Huston in saying that he expects tightness in plate to continue for some time.

Prices and Earnings

Because of higher overall production costs, the chemical industry has been successfully raising prices on a number of products where demand is taking care of supply. A number of price advances took place January 1, including formaldehyde. However, price difficulties are brewing in styrene, major raw material for plastics and synthetic rubber. Two major styrene producers are reported to have notified rubber customers of a cut in the price to 12 cents a pound from 16 cents by midyear, a hefty 25% reduction. The reason is that synthetic rubber makers take the position that styrene can be made for around 10 cents a pound, and have been threatening to build their own plants unless the price was lowered.

Last year was to some extent disappointing to chemical enthusiasts who a year before had looked for new high records in sales and earnings. This sparked major advances in a number of leading chemical shares. But while the year was a good one, it did not make records. Two leading firms, Allied Chemical & Dye and Du Pont, which had hoped for nice gains over 1955 for various reasons, showed a moderate drop in profits. Allied's results were due mainly to conditions in the ammonia business and Du Pont's to depressed conditions in the textile industry and lower prices for synthetic fibers.

What 1957 will bring in the way of profits is still a little difficult to gauge. Industry leaders on the whole look for moderate increases in sales with relatively stable prices on the average. Price increases made late in 1956 and scheduled for early this year will help in some instances. However, the decline in profit margins that took place in 1956 is likely to continue in 1957 because of the still mounting operating costs. Unstable world conditions seem to preclude the possibility of any substantial reduction in taxes.

Expansion

Chemical firms must plan at least two to five years ahead in budgeting their expansion programs because it takes about two years to build a plant of any size. Confident that demands in 1960 will be much higher than they are at present, chemical managements apparently have not been afraid of temporary overcapacity as long as they can get new plants built at competitive costs. The reason for the huge building of plants under fast tax write-offs was because a large part of the cost of the plants was paid for out of taxes. This led to overproduction in several products, notably in ammonia. Now government permits for fast write-offs are being sharply curtailed, but the funds flowing into the till from depreciation and amortization of plants already built will provide funds for many of the building programs for the next several years.

At present the chemical industry is maintaining its capital appropriations at a rate entirely beyond that of the other major manufacturing industries. According to a survey of third quarter (1956) appropriations authorized by boards of directors made by the National Industrial Conference Board under the sponsorship of *Newsweek*, the 16 major industrial groups were found, with six exceptions, to be down from 15 per cent (for stone, clay and glass products) to 68 per cent (for transportation equipment) compared with the same period a year ago. The chemical industry, one of the exceptions, was up the greatest amount, 168%, which brings its total for the first nine months of 1956 up 140% over the same period of last year.

The chemical industry spent about $1,500 million on expansion in 1956 and will probably spend more than this in 1957, making new high records. Plans on foot indicate that by the end of 1959 chemical capacity will be nearly 30% higher than at the end of 1956. It is also estimated that sales in 1959 should be nearly 40% greater than in 1955.

Quiet, Trouble-Free Operation · · · *Yours with*

The ANDREAS HOFER COMPRESSOR

For compressing gases to 5000 Atmospheres in laboratories and pilot plants, there is no equal to the Hofer Compressor. You can judge for yourself from the following features:

- Horizontal multistage construction with only *one* stuffing box.
- Metal packing . . . lasts for years under continuous operation.
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CEP

opinion and comment

"A happy new year" seems a fitting way to introduce *CEP's* first editorial for the year 1957. From every appearance, it does look as if 1957 will be a good year for the chemical engineer, as well as an interesting one, considering what is happening in professional activities and development. Never has it meant so much to be a chemical engineer. . . . Can this really be said to be true of the outlook for 1957? To avoid the oversimplification of a brief answer, the following is offered as substance to aid the reader in making his own decision.

Touching first upon the industrial economic barometer as having something very much to do with the well-being of most chemical engineers, the experts are reassuring. Expansion, they tell us, is at an extremely high level in the chemical and certain other of the process industries. But not without problems. Both steel and capital are in short supply. Inducing a kind of "get whenever and wherever you can" approach to expansion planning and procurement, the search and negotiation for delivery promises and price assurances will be at an active level. Estimates will be subject to earlier revision possibilities and the project evaluators will keep a wary eye on the need for measures either to compensate or provide the basis for allocation of additional capital. Escalator clauses have reappeared in equipment contracts. The Suez tieup, which looked to some commentators as if it might set business back so far in Europe as possibly to touch off a major recession over there, appears to be under control and of short duration. President Eisenhower's program for the Middle East appears to provide the means to better the standard of living of less fortunate nations. This calls for greater, more important participation on the part of the technologist, as was pointed out in *CEP* recently by Clifford C. Furnas, Assistant Secretary of Defense.

Turning next to what is happening in chemical engineering, 1957 will probably be looked upon as a year when a number of independent missionaries, without prearrangement, happened to converge their efforts. Never before, at least to the knowledge of this writer, have there been so many, with such good gospel, ready and active to arouse the chemical engineer to his destiny as a top administrator, a decision maker, a user of scientific techniques instead of intuition, a process scientist, a humanitarian capable of charming any dissident element, and so on. No less an authority than 1956 Professional Progress Award lecturer Robert R. White eloquently appeals to the chemical engineering profession to take serious stock of its abilities and methodology, and to adopt more scientific concepts as they can be instilled into its young comers. *CEP* will carry an article based on the White lecture shortly, and through 1957 will endeavor, as it has with this issue's OPsearch feature, to bring working information about new tools presented so you can understand them.

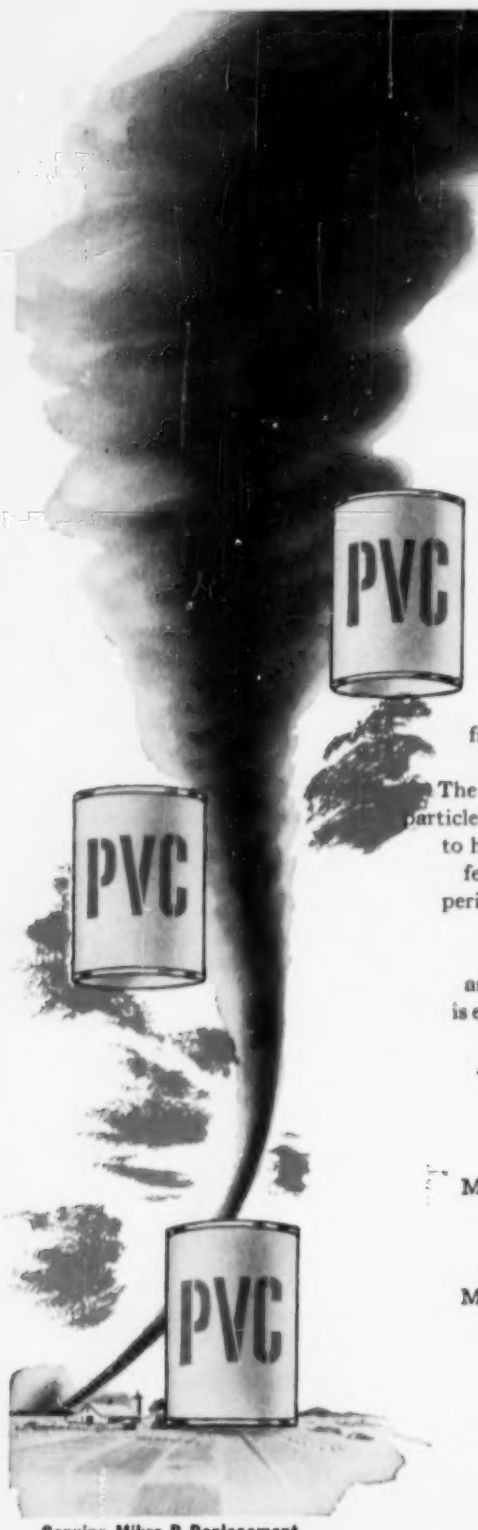
Coming finally to the engineering profession as a whole, little need be said in addition to that which has been said, in this issue of *CEP* and in recent issues. 1957 will see closer examination of some of the profession's knottiest problems (as indicated by the two articles in this issue on dissatisfactions), major moves toward better public recognition, and closer integration in the new engineering center and in other ways. As "Doc" Lewis pointed out in the 1956 Institute Lecture, "cooperation," rather than "coordination" (which means "control by someone else") will be the basis for successful unification.

J.B.M.

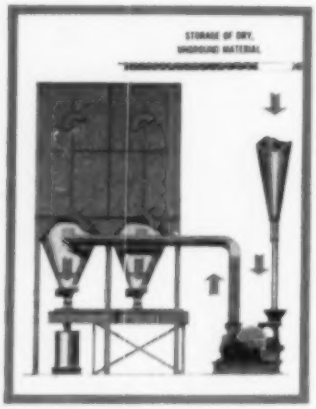
taming a plastic tornado!

Mikro-D Installation Sets New Standard in PVC Process

One of the nation's top Polyvinyl Chloride producers came to us recently with this problem: tame a plastic tornado from PVC spray drying equipment. Mikro-D tackled it with imagination and sound engineering and came up with the high efficiency system described here.



A Mikro-Collector, on the floor above the units shown here, separates the spray dried PVC from a veritable tornado of heated air . . . with efficiencies up to 99.998%. The design of this unit prevents sintered particles by eliminating prolonged exposure to high temperatures. The self cleaning feature of Mikro-Collectors eliminates periodic interruptions in processing and maintains maximum production. Conveyed to the Mikro-Atomizer, as shown at right, the PVC aggregate is efficiently reduced to uniform particle size of twenty microns (maximum). An air conveyor carries the ground product to a second collector above the drum loading station.



Mikro-D was chosen for this job because of their background in industrial product recovery. If you have a problem involving collection of sprays or dusts . . . pulverizing or air conveying of finely divided materials . . . Mikro-D are the people to see. Our engineers will work with you to produce the most efficient system for your product.

Genuine Mikro-D Replacement Parts available from large stock within 48 hours.

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METALS DISINTEGRATING COMPANY INC.

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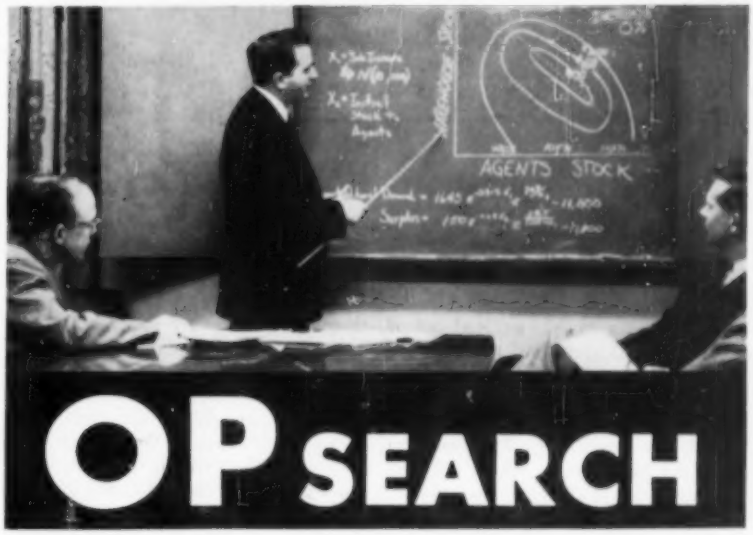

OPSEARCH

OPSEARCH IN ACTION—The initial inquiry has been made, alternatives defined and rated as to probable results. On the blackboard is a plotting of these results by principal variables, resulting in "surfaces" of expected cost inventory policy. The question now under consideration is whether the direction indicated is practical in terms of the real situations faced in the plant, warehouses, and distribution points. Shown by CEP's camera is a Union Carbide & Carbon Management Services Department group tackling a distribution problem. Left to right: John Stock, James E. Townsend, and Donald Styer. (Our appreciation to Mr. Townsend for this action example.)

OPSEARCH . . . Search for the Optimum . . . Operations Research . . . OR . . . Call it what you prefer, it's the new science of decision-aiding that is sweeping into "accepted practice" status with more and more firms in the chemical and petroleum refining industries. How about your firm? Can you . . . *should you* . . . be instrumental in giving OPsearch a try in your own organization? This issue of *CEP* contains enough information, in the opinion of experts, to give you and your associates all the way to the top enough to think about, enough answers to questions likely to come up, to enable you to make a basic estimate of what OPsearch might do for you, how it would be undertaken, and the results if put into action.

Why is OPsearch so important to the chemical engineer? The chemical engineer has always been concerned with *any* factors which affect his successful (and economical) production of product. In the more technical aspects of his work, he devotes much energy to collecting data to show what actually happens in pilot and full scale plant operations, and knows the value of such facts. He comes to recognize the interlocking of such work with other areas of activity in his company; he sees that production affects and is affected by policies in sales, finance, research, and personnel; he is sensitive to the conflict of interests that surrounds difficult decisions.

It is no wonder that chemical engineers, whether in executive capacity or not, should be interested in extending the use of scientific and engineering methods of thought to the broad problems of optimum scheduling, inventory levels, product formulation, and similar matters. Our training and experience leads us to desire precise descriptions and expressions as a basis for solving such problems. Today we are realizing that, with many problems, precise formulations are not possible. We are therefore beginning to rely on the use of statistics and probabilities for such solutions. OPsearch frequently makes use of such an approach.

The group of articles which follows was selected to give a unified picture of OR in the chemical industry. The first three articles deal with the definition of OR as seen by an experimental methodologist, a psychologist, and an executive. The four articles which follow present detailed stories of specific applications and of the kinds of "model" techniques used. These articles represent partial case-histories of OR projects—"partial" because they do not tell of the intense and lengthy effort required before the mathematical expressions ("models") could be constructed, or of the human problems to be overcome in putting the results to work.

—George D. Creelman *

* Mr. Creelman organized and was chairman of the Symposium on Operations Research at the 34th National A.I.Ch.E. Meeting (Pittsburgh) from which the OR articles in this issue were derived, and has organized the Symposium on "Scientists, Engineers, & Management Decisions—a Problem in Teamwork" to take place at the A.I.Ch.E. Spring Management Conference (at The Greenbrier), March 3-6, 1957 (For program, see page 77 of this issue.)

OP SEARCH

What it is—how it is conducted—what it will do

No branch of pure or applied science has ever been created by edict, proclamation, or spontaneous generation. Each branch has evolved out of the needs of society and the growing power of scientific concepts, methods, techniques, and tools. Operations Research (OR) is not an exception. Although its name dates back only to 1940, the needs out of which OR has arisen are as old as organized activity. Its methods and techniques appeared, at least in embryonic form, in the earliest days of science. In order to understand the development and significance of this new science in the industrial context, however, we need go back only as fas as the industrial revolution.

The industrial revolution brought with it not only a division of manual labor but a division of managerial labor as well. With the growth in size and complexity of industrial organizations that resulted from the mechanization of production, it was no longer possible for a single person to manage effectively all the functions of an organization. This led to the creation of managers of production, marketing, finance, personnel, and so on. When further growth took place, even these managerial tasks were further divided. For example, in production, managers of procurement, quality control, maintenance, decentralized factories, etc., appeared.

The technical foundation of the new industry created a need for the application of science to the solution of the problems that arose in the newly organized functional components of the business. For example, physics and chemistry were applied to the solution of problems associated with mechanized production. Special methods, techniques, and tools were developed by the scientists to handle these problems, and thereby these applications came to define areas of applied science that came to be known as chemical and mechancial engineering. Once the physical and chemical problems associated with production were largely solved, the contribution of the worker took on great importance and the scientific study of his behavior in the production context led to the creation of industrial engineering. Development of new power sources and raw materials led to the creation of electrical and metallurgical engineering as well. Similarly, the fields of marketing research, applications engineering, industrial economics (the economics of the firm), accounting, personnel psychology, and industrial sociology came into existence.

History and Managerial Functions

The point of this excursion into well-known history is to emphasize the precursors of the application of science to managerial problems, for OR is the most recent of these applications. It is distinguished from its predecessors, as they are distinguished from each other, not so much by its techniques and tools as by the class of phenomena which it studies. This class of phenomena may be called *executive problems*. The nature of this type of problem is best understood by reference to the same history we have just reviewed so briefly.

With the division of the managerial function, the necessity for coordinating managerial functions and the associated functional components of an organization itself became a new management function. the executive function. Such coordination is required at the company or corporate level and may also be required at the departmental level as well. It is needed wherever the job to be done is functionally divided among distinguishable organizational components.

Each organizational unit tends to make decisions in such a way as to optimize its own performance. Such decisions, made independently by each component, seldom add up to the best over-all performance for the whole organization. Coordination of decisions, then, is the function of the executive.

Executive decisions are complicated by the fact that multiple objectives are always involved, and these are seldom completely compatible. For example, maximizing short run profits, improving market position, and acquiring product leadership may come into direct conflict in planning an annual budget.

The demands on the executive's time are usually so great that he cannot spend the amount of time required to identify all these conflicts and to evaluate systematically the alternative policies in this decision complex. Realization of this fact led to the emergence of the professional management consultant who offered two valuable commodities to the executive: time to reflect, observe, and analyze, and experience with such problems in other contexts. It should be noted, however, that the consultants' method was no different from that of management. It was only natural, then, that exploration into the possibility of applying science to this class of problems should have taken place. Sallies into this "no man's land," which was populated by intangibles as well as conflicting objectives, were made by each of the applied sciences: chemical, mechanical, industrial engineering, etc. But it became increasingly apparent that no one discipline had at its command all the contextual and methodological knowledge necessary for effective solution of these problems. The necessity for attacking these problems with the widest possible range of scientific knowledge (physical, chemical, biological, psychological, social, economic, etc.) and the largest possible repertoire of scientific methods, techniques, and tools became increasingly apparent.

Scientific Methods and War Emergency

But it was not until the military emergency, which arose in Great Britain at the beginning of World War II, created an urgent need for effective (military) executive decisions that interdisciplinary teams of scientists and engineers were formed to attack such problems. The immediate and phenomenal success of these teams is now a matter of history. Their use became widespread in Britain and, within a year (by 1941), had spread to this country.

After the war, scientists and engineers who had been engaged in this activity—which came to be known as Operational or Operations Research—moved back to universities and industry. This movement took place slowly in this country because of the considerable expansion of military OR

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OPERATIONS RESEARCH

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activities which occurred at the end of the war. The Korean crisis, however, provided the spark which ignited the industrial fire that has blazed ever since.

There are now over a thousand operations researchers working in and for industry. Several hundred of our most successful companies have their own operations research groups, and the OR services of several dozen consulting firms, research institutes, and collegiate research groups are available for those which do not have their own OR activity. The Operations Research Society of America was formed in 1952 and now has almost 2,000 members. It publishes a highly successful bimonthly journal, *Operations Research*. A related society, The Institute of Management Sciences, has since been formed, and it publishes a quarterly journal, *Management Science*. Corresponding societies exist in Britain and France, and others are in formation in a number of European and Asiatic countries.

The Essential Characteristics of OR

With this evolution in the background, we can turn now to an examination of the essential characteristics of this most recent addition to the family of management sciences, Operations Research.

It is hardly necessary to point out to a group of scientists and engineers that clear-cut distinctions between the various branches of science and engineering do not exist. In fact, it is difficult to distinguish science and engineering. Since each science and branch of engineering is an evolving and dynamic activity, it is continuously engaged in its own redefinition, particularly in the early stages of its development.

With these cautions in mind, we can attempt a definition of Operations Research:

OR is the application of scientific method to the solution of executive-type problems in organized systems. Its objective is to provide the executive with an objective basis for selecting policies which are best for the organization as a whole. It is this *whole-istic* approach to organized systems, then, that is one essential characteristic of operations research. Also, in OR, science is applied to these problems by teams of scientists and engineers drawn from various disciplines. Finally, an OR method of attacking these problems has evolved, one which is uniquely well adapted to the type of problem involved.

A consideration of each of these essential characteristics follows:

THE WHOLE-ISTIC APPROACH

The whole-istic approach consists of a systematic exploration of the interrelationships between a decision or operation in one part of an organized system and all other parts. In principle, this approach has long been extolled and supported. But its systematic application in the scientific investigation of the executive-type problem is relatively recent. Practice lagged behind principle because it was not until recently that scientific methods and procedures were developed which were capable of coping with the resulting complexities.

It would require at least one detailed case history to illustrate the whole-istic approach in an adequate way. Since this is not possible here, a brief reference to one case may help fill the gap.

A commercial airline asked an operations research group to determine how frequently it should conduct classes for the training of stewardesses and what size these classes should be. This rather limited problem was formulated precisely. By methods to be discussed below, a decision rule was obtained which enables those who administer the school to run it in such a way as to minimize the sum of the costs involved.

The details of this solution are not of importance here. What is important is the fact that the research team was able to show that the effectiveness with which the school was operated was very sensitive to the statement of requirements for a stewardess provided to it.

Consequently, an investigation of how these requirements are determined at each base was undertaken.

This led, in turn, to the development of a procedure for minimizing the number of stewardesses required at each base.

But this investigation revealed that a base's requirements for staffing were sensitive to the assignment to that base of flights and that the total system's requirements were sensitive to the number and location of bases and the assignment of flights to them.

A study was then undertaken to determine how many bases there should be, where they should be located, and how flights should be assigned to them so as to yield the best possible performance of the total system. But flights could not be assigned to bases without considering the disposition of the male crews.

Consequently, the study was generalized to consider the total crew. Once each of these aspects of the system's operations had been analyzed, the results were synthesized and over-all planning procedures for training and utilization of personnel were developed.

Further studies of utilization of aircraft, maintenance policies, etc., were suggested by the study because of relationships which were revealed. It is expected that these studies will be undertaken in the near future.

This brief discussion helps underline two important aspects of the whole-istic approach:

(1) the problem with which the research begins is not nearly so important as the problem with which it ends, and

(2) in a real sense, such research is never completed but is continuous.

It may, of course, be terminated, but each study reveals further possible generalizations. This process of successive generalization, however, may reach a point of diminishing return at which it may be more profitable, in terms of investment in research, to take another line of research.

THE INTERDISCIPLINARY TEAM

The advantage of being able to study an operation from as many points of view as possible is too obvious to require discussion. Another advantage of the interdisciplinary team, however, is not so obvious.

Nature presents problems in an unlimited number of different contexts. It is much more frugal, however, in the number of different *forms* or *structures* of the problems it presents; that is, the same type of problem may appear in many different contexts. "Same" here refers to form or structure. The research scientist, particularly one trained in the use of mathematical methods, has the ability to extract the form of a problem from its context. By so doing he reduces it, in many cases, to a type of problem with which he is familiar, even though he has never before encountered the problem in the particular context in which it appears. This process of formal abstraction enables him to bring to bear on the solution of the problem scientific methods, techniques, and tools which had hitherto been confined to the realm of pure science or

specialized areas of engineering.

By having an interdisciplinary group of scientists perform this abstraction, a wide range of possible approaches to the problem is revealed and can be comparatively evaluated. The result is usually the synthesis of a new, or selection of an available approach which is uniquely adapted to the particular context within which the problem appears.

Consider, for example, the stewardess school planning problem referred to earlier. Analysis of this problem revealed that it was an inventory-type problem, even though such problems usually arise in a production or purchasing context. Once this fact was revealed, a host of possible solutions were evident. We shall shortly consider what is meant by inventory-type problems and have something to say about the available approaches to their solution.

It is worth noting at this point, however, that scientists knowledgeable in servomechanism theory have found that this theory is applicable to the solution of certain types of inventory problems.

Similarly, chemical engineers have demonstrated that flow theory can be applied to other problems of this type.

The Operations Research Method

The systems with which OR deals are obviously of such a nature that it is either not practical or not feasible to bring them into a laboratory in order to try out alternative decisions. Furthermore, the possibilities of experimenting on them in their natural habitat is almost equally difficult. Consequently, in most cases, the operations researcher is in much the same kind of position as that in which the astronomer finds himself. Experimentation, in the usual sense, is precluded. He proceeds, then, much as the astronomer does.

A representation or model of the system under study is constructed, one in which the relationships between the various aspects of the system are expressed quantitatively. The model of the system, rather than the system itself, can then be manipulated to determine the effe of various policies applied to the em.

More specifically, the operations researcher begins by analyzing the system in order to construct a measure of the effectiveness of the system's performance, a measure which incorporates within it the various organizational objectives, conflicting as well as nonconflicting, and their relative weights or importance. This is a very difficult task requiring the application of all that *decision theory* and *value theory* have to offer. Once such a measure is obtained, a model of the system is constructed, one which has the following form:

$$E = f(x_i, y_j).$$

E represents the measure of the system's effectiveness. The x_i represent the various aspects of the system which are subject to management's control, and the y_j represent those aspects which are not. f represents the mathematical relationship between these variables and the system's effectiveness.

Once such a model has been constructed, the next step is to determine for what values of the controllable variables the system's effectiveness is maximum. This determination may require the use of analytical or numerical procedures ranging from the very simple to the very complex. The result is what might be called a "tentative solution" to the problem. This solution must then be tested. Such testing frequently involves experimentation. Once the solution is tested and put into usable form, it is necessary to design a procedure for *controlling* its application. This point requires some explanation.

The systems with which OR deals are seldom, if ever, static. They are subject to either determinate or random variation. That is, the values of the controlled variables change in time. A procedure for detecting changes of significant magnitude must be developed and procedures for appropriately adjusting the solution must be designed.

Finally, the results of the study must be implemented. Since implementation in an organized system which already has customs and procedures of its own is always a difficult task, the insertion of new decision-making procedures in an established organization must always be done with considerable care. Detailed advanced planning is thus required.

RECURRENT PROBLEM FORMS

As indicated earlier, problems with the same or related structures arise in a wide variety of contexts. Several types of problems have arisen with such frequency in the application of OR to industrial problems that mathematical theories have been developed to facilitate their solution. These theories consist either of very general models and the solutions extracted from them, or a family of more specialized models and solutions with a principle of generation of other specialized models to handle specific cases as they arise.

The development of several of these theories was already under way when OR was organized into a self-conscious activity. Consequently, in listing these theoretical developments a claim for neither origin nor ownership is made on behalf of OR. Most of the developments in these areas in the last five years have been made under the name of OR, and, certainly, most of the applications have been so made.

The principal developments have been as follows: inventory theory, allocation theory, waiting-line theory, sequencing theory, replacement and maintenance theory, game theory, bidding theory, and search theory. It is not possible to consider each of these at the present time. It may be helpful, however, to discuss briefly the first three of these since they account for a large majority of the applications of OR which have been made in industry.

Inventory Theory

An inventory problem can be defined as one which involves the determination of either (a) the frequency, (b) the quantity, or (c) the frequency and quantity of acquisition (by purchasing, production, training, etc.). This type of problem arises in a context in which the conflicting objectives usually can be represented by a set of costs. On the one side, there is the cost of carrying inventory which increases with the size of inventory. On the other side, there are sets of costs, any one, or combination of which decreases with increases in inventory. These are the set-up costs associated with acquisition, shortage, delay, or run-out costs, purchase price, and the cost of hiring and firing. A solution to such a problem consists of finding that quantity or frequency of acquisition which minimizes the sum of the pertinent costs.

Although theoretical work in this area dates back to the development of the initial economic lot size equation in 1915, in the last few years the theory has been generalized in very significant ways. Variations in demand, acquisition lead time, delivered quantities, and so on, can now be handled. Techniques are available for handling the problem in a dynamic as well as a static context, that is, one in which future decisions must be considered in making the present one. Recent developments have also made it possible to optimize a system involving acquisition at each of a hierarchy of storage points, for example, at factories, warehouses, and distributors.

Inventory problems have arisen not only in the usual production and purchasing contexts but in many other areas as well. The stewardess training case has already been discussed. Another unusual application has been in determining when and how large a turboelectric generator should be added to an electric utility system.

The questions of quantity and frequency are both apparent in the stewardess training problem. The salaries paid to the excess of stewardesses in the system correspond to an inventory-carrying cost. There is a set-up cost associated with preparing for a class and processing the applicants. There is also a cost associated with a shortage of stewardesses in the system.

In the utility case the depreciation on unused equipment is a cost of inventorying a productive capacity. Lack of such capacity results in a shortage cost involving unsatisfied demand, and, more seriously, the disfavor of the public utility commission which can be expressed in unfavorable decisions concerning rates.

Through the use of inventory theory, it has been possible to automatize purchasing and production control systems. By programming the solution, which takes the form of a mathematical decision rule, into a digital computer, and by inserting the pertinent information into the computer's memory, it is possible to handle large acquisition systems quickly and at low cost.

Allocation Theory

The most restrictive form of an allocation problem can be described as follows:

(1) There is a set of tasks to be performed.

(2) Resources (facilities or materials) are available for performing these tasks.

(3) There are alternative ways of performing at least some of these tasks.

(4) Not all of these alternatives are equally effective.

(5) The available resources are not sufficient to perform each and every task in the most efficient way.

The problem, then, is to allocate the available resources to the required tasks in such a way as to yield the best possible performance of the system as a whole.

For example, a steel mill produces only to order, but it can process each order in an average of six different ways. Each way is called a "production practice." The alternative practices vary in cost. If each order to be filled in a planning period (a week) is programmed for the least costly practice, the result is an overloading of certain machine centers and an underloading of others. The problem, then, is to program the orders in such a way as to minimize the total cost of production.

A similar problem arises in determining from which factories to ship to which warehouses so as to minimize total transportation costs.

These problems, like many allocation problems, are solvable by *linear programming*.* (Nonlinear programming procedures are now becoming increasingly available.) Linear programming makes it possible to solve problems which, only a few years ago, presented insuperable problems of calculation. Although many allocation problems now can be solved by hand in reasonable times, most of the new calculational procedures have been programmed for electronic computers.

Two less restrictive forms of the allocation problem also are quite common. In the first, the tasks to be performed are at least partially subject to management control; in the second, the resources are at least partially subject to such control.

The first of these types of problems arises, for example, in determining what type of time to add to a product line so as to achieve a more balanced production load.

The second type of problem arises, for example, in determining where to establish a new facility, such as a warehouse, factory, or retail outlet, or how many facilities to have, where to locate them, and what tasks to assign to them. Determination of the size and location of airline bases (as previously discussed) was a problem of the latter type.

Many of these less restrictive allocation problems are solvable by linear and nonlinear programming procedures.

Waiting-Line Theory

A waiting-line or queuing problem arises in processes which can be characterized in the following way: (1) There is a service point at which one or more service facilities are available. (2) Units requiring service arrive at the service point. If arrivals are too frequent for the facilities, the arriving units (called "customers") must wait. If, on the other hand, arrivals are too infrequent, the facilities must wait, that is, remain idle. Both types of waiting involve a cost. Either the arrivals, facilities, or both can be controlled. Whatever the controllable variables, the problem is to set the controllable variable(s) in such a way as to minimize the sum of the costs due to waiting time of customer and facilities, and, in some cases, the cost of the facilities themselves.

Waiting-line problems involving control of facilities have been solved, for example, in determining the number of toll booths to operate at bridges and tunnels, in determining the optimum number of loading and unloading docks for ore boats and delivery trucks, and in determining the number of locomotives required to operate a railway classification yard under different work loads (arrival rates).

Problems involving control of arrivals (scheduling problems) have been solved, for example, in scheduling the operations of a truck fleet, and in scheduling the operations of maritime fleets.

Waiting-line theory, initiated in the study of telephonic switching operations, has been considerably extended in recent years. The application of probability theory and, in particular, stochastic analysis, has been very fruitful in yielding mathematical tools for solving a wide variety of waiting-line problems, including those involving multiple-service facilities, special-service facilities, and service-priority systems.

Many complex waiting-line problems not yet solvable by analytic procedures are solvable by simulation, in particular, by use of Monte Carlo procedures.

*** Linear programming techniques will be described in a forthcoming issue of CEP, in a paper by Cooper & Charnes, presented in the same symposium.**

Conclusion

It should be emphasized, by way of concluding, that a whole, real problem is seldom encompassed by a model of any one type: inventory, allocation, waiting-line, or any other. The real problem usually involves a combination of these and one or more not readily classifiable. We are a long way from the routine application of ready-made procedures. Each OR problem presents a creative challenge and at least partial charting of new courses. Herein lies the fascination of this new science to those trained in many areas. Herein also lies its ability to attract some of the best minds from other sciences. Put another way, the fascination of OR does not lie in what it is, but in the fact that it is being made into what it will be.

OPsearch and
TEAMWORK

How can individuals in industry—particularly engineers, mathematicians, scientists, and managers—work together more effectively in groups? The answer lies partially in a better realization of the nature of teamwork and a knowledge of the reactions and positions of the other members of the group. So says a consultant to industry who specializes in getting committees to resolve managerial problems in a manner far removed from the traditional lowest common denominator of the most timid soul among the committee members.

Richard Wallen | Creelman Associates, Cleveland, Ohio

The most obvious advantage of a team lies in the fact that more creativity is possible in a group effort. In a complex problem one must use all available resources to locate the area which needs OR, to set up the model, and to collect the data necessary for the problem's solution. Finally, one must attend to the actual implementation of the changes suggested by the solution.

There are advantages in the use of a team which are not immediately apparent unless one considers the emotional side of human behavior. As an illustration: During long and costly projects, people will encounter blocks and discouragements that lead to apathy or resignation. Anyone familiar with any kind of research activity will recognize this. It is now believed that it is easier for people to face periods of discouragement if they are welded together so that they can provide emotional support for one another. If teams are used, a long research project can continue without losing the creativity of an individual because he happens to be disturbed t a given moment.

The idea of using people to help develop new ideas is not new. There are a number of different ways in which this may be done. Figure 1 is a diagram of one way in which it is being done. This is a one-to-one relationship. An executive needs to make a decision, solve a problem, or get an idea. Typically, he will consult the engineer, the scientist, the mathematician, and others, one at a time. But this is not a team. This is simply cashing in on the ideas of separate individuals. The total amount of influence and stimulation possible is very small. This arrangement has been *called* a "team approach," but it is not so in reality, as will be shown.

Figure 2 is a diagram of the type of communication which characterizes a *genuine* team approach. The four different geometrical figures show four different personalities who are going to unite into a team. The lines show the interconnections possible between the people on the team. The opportunity for interstimulation, for sharing of ideas, for creativity, for emotional support, and so on is tremendously increased. This is one of the marks of a team as opposed to a group of individuals.

Fig. 1. "Team approach"—so-called.

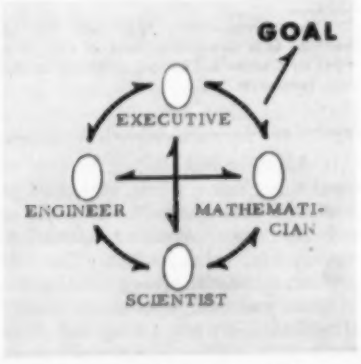

Fig. 2. Genuine team approach.

The basic requirement for a genuine team is that it share a commitment to a *common* goal. It is necessary, however, for any group that really wants to form a team also to take into account the *individual* needs and personality of each member of the team. We cannot require conformity in all respects from every individual. The minute we do that, two very destructive things happen: we lose the uniqueness of the individual contribution, and we lose a team member. Suppose one individual on a team is easily insulted. This fact must be understood by the other members of the team, and arrangements must be made to deal with it. If they dismiss his contribution and simply call him "temperamental," they reject one part of the resources they need. He will not commit himself to the total task of the team. How is he to be dealt with? There are no ready answers for this, but there *are* ways through which such people can learn to work with others.

The third thing that must be true of a genuine team is that there must be full, accurate communication among the members. They must feel free to speak to one another. Frequently, when an executive calls people in and asks for their opinion, no sense of freedom is established. The end result is that they do not give all they could possibly give. This is reminiscent of a story about the Hollywood executive who told a group of new executives that he wanted no "yes" men among them. He added, "I want you fellows to be able to say *no* to me even if it costs you your jobs." That is no way to promote free communication.

Team Problems

What are some of the difficulties OR teams face? They happen to be peculiar because a true OR team is formed of scientists, engineers, and management. One of the difficulties is the difference in vocabulary. The executive does not speak the same language as the mathematician, and the two may have trouble explaining themselves to each other.

Another factor that causes difficulties is that commitment to the goal of solving a common problem may be only on the surface. Actually, people may have personal goals that they are trying to reach, too. One man may be much interested in getting his work published. Another may be equally interested in getting a promotion. Human beings are complicated; they do not always tell all the goals they have. Indeed, sometimes they do not even know themselves. These individual goals may actually interfere with the total teamwork approach. One must

work out techniques by which individual goals can be realized at the same time that the group goal is being reached. In many instances, this is more possible than one might believe.

This team approach must face still another difficulty. We live in a society that is individually competitive. We have been brought up in school where grades are given on the basis of our individual efforts. In teamwork we have a cooperative society, and we are reversing something that we have all been brought up to believe. One of the ways this training shows itself is in "idea possessiveness": "I want to get credit for my own ideas, not give them to a team." This problem must be faced, because it is true that the team must function in a world where ideas still pay off for the individual. But it is also true that when we operate as a team, there will be ideas emerging that cannot truly be labeled as belonging to any one person.

Solutions?

How can some of these difficulties in building an OR team of management and scientists be resolved? First we need, for such teams, skilled and democratically oriented leaders who know how to help this kind of group find its own way. Such leaders do not try to persuade a team to adopt their point of view but rather to help it unite and direct itself. This is something which one doesn't learn by reading books. It takes special training and experience.

Second all team members, at some time, must learn to accept the reality of personal feeling. Gradually, they must find ways in which to bring personal feeling out into the open. Only if this is done can people unite in a reasonably happy relationship.

Finally—and this is one of the fascinating developments in the study of small groups—the team must learn how to study its *own* problem-solving behavior. One can teach teams to become self-steering in a sense by getting them to ask, "What's happened to us in the last half hour? Why have we bogged down?"

It is of prime importance to recognize that a team is a great deal more than a collection of individuals.

It has its own emotional side as well as an intellectual side. Unless the emotional side of the team relationship is taken care of, the intellectual side cannot go ahead. OR methods now available permit us, self-consciously, to build more effective teams than ever before.

Presented at A.I.Ch.E. meeting, Pittsburgh, Pennsylvania.

An Opsearch study helped International Minerals and Chemical get the most out of this $1 million dragline with a 17½-yard bite on a 185-foot boom.

Opsearch — A MANAGEMENT POINT OF VIEW

Thomas M. Ware | International Minerals & Chemical Corporation, Chicago, Illinois

An operations research study, started several years ago by International Minerals & Chemical Corporation, resulted in a marked improvement in operating efficiency of the world's largest dragline used in stripping phosphate rock for fertilizer production in Florida (*1, 2, 3*). This study, and others which followed, have led to an appreciation of some of the problems management faces in getting an OR study started and in putting the results to work in industry. The purpose of this article will be to describe some of these problems, and these situations.

Dragline and Human Relations

Returning to the case of the dragline, I.M.C.'s mining management sees that it should be possible to increase the productivity of these large and expensive machines. The project began with the improving of the entire working space of the operator, by revising his controls and by giving him modern instrumentation (*4*). This was a major job; however, the operator now has a much pleasanter job, and he can run the machine better.

While working on this study, the consultant employed for the job discovered how it would be possible to increase the cubic yards mined each day by changing the sequence of mechanical moves of the machine. An OR project was approved, and the special staff group, working with the consultant, went ahead with formulation of the problem and its solution. To the amazement of I.M.C. group, we ended up with a three-page formula containing twelve variables (after eliminating many more)—a formula that could be solved only by the most advanced electronic computer then available. The computer's solution then had to be translated into tables and charts for daily use to obtain a proved economic optimum production rate. The next step was to help men in production learn the use of the new instructions and charts.

Other articles printed in this issue describe mathematical models and their solutions, but the point to be emphasized here is the series of human relations problems that were to become a critical part of this job.

Mr. Ware is administrative vice-president of International Minerals & Chemical Corporation.

Communications Hitch

The necessity for revising the cab and the controls had made the consultant and the staff engineers acceptable to the operators and local management. Therefore, when the time arrived for undertaking scheduling study, there was already some acceptance of the people who were needed to define and select the variables, and to set up the equation to represent the system. This was a slow, hard job. The study group had to learn about models and the interaction of variables, and the consultant had to learn about the headaches of day-to-day operation.

WHY WE NEED OPERATIONS RESEARCH

From my own experience I believe OR will become one of the truly powerful management tools for unraveling modern business complexities. Its place in business, as I have seen it, comes from the need for scientific support for today's management decisions—decisions, in particular, that result from modern competition. The generations before us did quite a job in order to produce a product, to produce it in just hundreds or thousands of units. Today's generation is confronted daily with production in terms of millions of dollars and billions of units. To me, OR has today most of its applications because vague rules of trade and hunches can't apply to situations of such complexity. There's too much at stake.

The real function of OR, I believe, is putting a new perspective on the relationship of the parts to the whole. That doesn't mean the same old parts that have always been there; when you get an OR team together, you find parts that people have previously been unable to categorize. Or you may find that these parts take on different characteristics from those you've known before. OR brings a new perspective.

Edison was wonderful. His technique was to get a solution by trial and error. He produced some pretty fine solutions; nobody questions that. We must today go on from there—that's our heritage. We must examine the system, look for the optimum solution and continue to improve as we go along. That means not only using a scientific approach, but also putting some pretty hot talent on the job.

Finally, the data were collected and run through the computer, the results being put in usable form in a voluminous report which I received. At this point there was made an almost fatal mistake. I was busy and handed the report to one of our executives, asking him to review it, expecting he would do a thorough job of introduction so that the operating people could understand and interpret it. Well, he was busy also, so he just handed them the report. Boom! The lid blew off, and one of our key men decided he was going to quit, right then. He clearly regarded all the fancy theory as silly. The interpretation was missing. The basic understanding was missing. The motivation to use the report was needed badly. Finally, resurrection was managed, and that man, who had been with us for twenty years, has subsequently played a significant part in many of the OR projects. As a matter of record, he has come up with certain ideas that have evolved in this particular area. This example serves to illustrate how staying on top of the job is vital and so is following through until the results are part of day-to-day practice.

Probably more than any one thing, successful application of OR depends on a liberal attitude and a human approach. That combination is the common denominator for all the OR work. OR tries to clarify relationships—relationships that make up a complex situation. Management has to have the questioning, open-minded attitude. This is fundamental, or there will be no research on operations. OR needs freedom to wander, wonder, question, experiment, and to ponder causes and effects.

Summing up what has been covered so far, OR may be termed a science applied to complex management decisions. It means looking for unusual and different clues—things that have escaped us—by teaming up with specialists. OR is aimed at keeping the research mind creative and effective; at developing and introducing new ideas; at the areas of experience and vague hunches, the areas which are often talked about as management prerogatives. Courageously, OR aims at questioning management decision processes; hopefully, OR strives to push ahead mental frontiers.

With anticipation of some questions which are correctly raised as a company seriously considers going into OR, the following are asked—and answered—as an aid to the reader:

Should You Have OR?

Large companies with people who are able to understand and grasp its meaning and want to put it to work would be well advised to start developing their own team internally. Success requires an open mind in top management. This must be backed up by encouraging a few people throughout the organization to continue internal education and help prepare receptive attitudes for the larger projects as they come along.

Consultants—Do You Need Them?

Consultants move you much faster; they give you good guidance to help train people. They're stimulating, and, of course, have the additional advantage of being outside, and are therefore more objective. Then, too, a clever management can get things done with consultants that would be much more difficult with only their own people. Be careful of the qualifications, however, of people chosen as consultants.

Do You Have an Objective?

One has to have an objective clearly in mind—the spark of an idea somewhere—a goal. Some plan is a must. Be very sure of yourself, and that you're going to push a study and stick to it. There is no half-way effort permissible in this field; it takes real determination to do an OR job right. OR should not be used just for the sake of keeping up to date; it's amazing that even today there are some who feel they have to have OR—and other developments—for this reason.

Can You Use Staff Help Effectively?

A company today has many different staff functions, and bringing each in at the right time and the right place and having each do its part is really quite a job—let alone trying to bring in some brand new idea that threatens to do all the things that the OR people are talking about. One should be continually alert to the sound reasons that often lie behind resistance to staff ideas. But if your company can use staff help now, they are more likely to tackle an OR job well.

Are You Ready to Follow Through an OR Project to the Stage of Using the Results?

If one gets into OR work, it should be on the basis of being prepared to interpret the results in a way that will build confidence. One can't just give the rest of the organization a formula. It seems likely that others may be faced with a situation as I was one time when I had to bring in all our top brass from Chicago and everybody above a certain level in the rest of our organization to take them through a derivation of the three-page formula referred to earlier and make it possible to follow each step of its derivation so that at least they could say, "Well, now I understand how that was done." Then they have the basis for accepting it, which enables them to have confidence in using it. Admittedly, undertaking such interpretation takes a certain amount of courage—real courage. . . .

What Is the Level of Maturity in Your Organization?

OR is not for organizations made up of boys trying to prove that they are men; nor is it for organizations that are unable to see the need for change. A mature organization is one where management people can freely share ideas without fear, where new ideas can be examined objectively. Sometimes the first step in introducing OR will be to get management to take a good look at its present decision-making process and to build a team spirit. One of this new science's most interesting qualities is that it sometimes appears to take an OR project to help management grow toward real maturity. . . .

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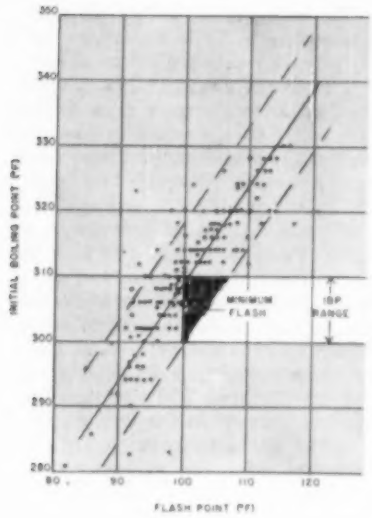

Fig. 1. Varnolene—I.B.P. vs. flash naphtha rerun unit.

OPERATIONS RESEARCH

Opsearch in PROCESS ENGINEERING

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Over a period of six years, operations research has been used to study and make recommendations on varied activities of Standard Oil (Ohio). For example, such diverse operations as product quality, crude oil production, accountability, safety, and maintenance have been studied and affected as a result of the work of the operations research group.

Organization

At the present time four men on full time comprise the group. Activities are conducted *informally* by teams ranging from two men to as many as twelve in cooperation with the existing organization of the company. For example, the largest group at this time is working on the problem of safety; it comprises two men from Operations Research, four from the Home Office Industrial Relations Department, and six safety engineers from the refineries.

General Activities

PLANNING AND FORECASTING

To study planning in purchasing, transportation, and utilization of crude oils, linear programming methods were set up. Experimentation with these methods has been carried out for two years. Several results have evolved from this study. First it has been helpful in indicating where operations should be changed to improve the profitability of the system. Also it has shown that inability to predict operations accurately limits the profits which can be obtained. Consequently a large portion of the work is concentrated now on the data system and forecasting problem on which statistical methods have been helpful in measuring and improving forecasting ability. Time series analysis and various forms of analysis of variance also have been used in an attempt to improve ability to predict operations.

The work being done on the problem of safety further illustrates the broad scope of application of these methods. Traditionally, the lost-time accident has been the accepted measure of safety performance. Probability theory and statistical control charts helped demonstrate why this measure was inadequate in the short run. As a result, more sensitive, improved measures of effectiveness were developed by the safety engineers, and control charts now are used universally to measure safety performance. Sampling also has been helpful in analyzing the approach to the entire safety problem. By this method, the group has learned that efforts to stimulate interest in safety have been effective; and that analysis of jobs for hazards has been less effective. Further, it has shown through this method that management and workers differ greatly in their appraisal of safety vs. time or inconvenience to take preventive action. Besides leading to improved measures of performance, safety studies have helped guide the total approach to the problem.

Maintenance

Basic studies in maintenance have dealt in a helpful way with problems of equipment failure and piping-corrosion rates. A present aim is to schedule necessary replacement, based on the probability of failure, of all piping equipment in the refinery. A routine statistical calculation will be made eventually on a computer for 70,000 pipes in the refineries.

Statistical methods and sampling have been helpful in two other maintenance problems. For example:

a. in determining storehouse inventories and the number of clerks needed to dispense goods at the storehouse window.
b. in measuring and comparing methods for predicting time required by an individual craft on a given job.

Case Histories

NAPHTHA RERUN UNIT CASE STUDY

In this case, a distillation unit for two light products had been giving low-volume yield and erratic quality over a number of years. The refinery finally decided to attempt statistical control methods and invited the operations research group to join the team tackling the problem.

At the beginning of the project, members of the team intuitively felt that the problem was one of control of the drawoff rate of the two major product streams from the unit. These two products are known commercially as Varnolene and D. C. Naphtha. Before the equipment was purchased to control these rates, it *was*, however, agreed to determine what such equipment could accomplish. A factorial experiment to study the effects of these and other factors was conducted by the plant. Table 1 illustrates the experimental design selected. This design is known as a complete factorial in which all combinations of all variables are run. For example, the two products were run at both high- and low-drawoff rates. D. C. at the high and low rate is run with Varnolene high, and D. C. at high and low rate is run with Varnolene low. This is done to measure any interaction of the variables upon one another, as they

Table 1.—Experimental Design—Varnolene End Point Data

Varnolene Drawoff Rate	D. C. Drawoff Rate		High (B)		Low (A)	
			Sample 1	Sample 2	Sample 1	Sample 2
High (B)	A	Setting	405	424	376	390
	B	Setting	402	406	420	417
Low (A)	A	Setting	392	414	418	419
	B	Setting	422	420	388	378

influence the results. Ordinary tests in which variables are changed one at a time do not measure this phenomenon.

All combinations of settings were repeated, as setting *A* and setting *B*, to measure the variability in the unit. All samples were carefully split and sent to the laboratory "blind" to measure testing deviations. These splits are called sample 1 and sample 2 in the illustration.

Results of this plant experiment indicated the following:

a. **Little, if any, improvement could be obtained by installing control equipment on the two drawoff rates at this time. Other sources of variation would have to be identified and eliminated first.**

b. **Due to laboratory measurement deviations, product centered perfectly in the specification ranges would be passed on all tests only 15 per cent of the time. Since control called for adjustment whenever something was "off spec," over-adjustment would result. Therefore, the plant group measured their testing deviations and consequently instituted an improvement program.**

Since the experiment indicated that establishment of control on the drawoff rates would *not* be helpful, then other factors were considered. For example, process engineering personnel located improperly operating instruments and improperly functioning components of the system. Without these findings the ultimate results could not have been obtained. Thus the experiment helped the plant people direct their efforts from an area which could not prove beneficial to a very fruitful one.

A next step was to examine potential relationships between the various quality characteristics. Figure 1 illustrates the relationship, obtained by plotting production data, between the initial boiling point and the flash point of the Varnolene stream. Test deviations would account for most of the variation around a line fitted through the operating data. It was interesting to compare minimum and maximum specs on initial boiling point with the plot of production data. The minimum was 300°, the maximum 310°, with a minimum flash of 100° also specified. Thus the specs could be considered as a box on this chart with operation moving back and forth along the line fitted through the data. Best performance would just cut the corner of the box. At this point of best operation, the product would be rejected about three fourths of the time with any test error at all.

References to the literature on physical properties of pure hydrocarbons and mixtures to check the agreement of the initial boiling point-flash relationship did not give an absolute answer, but did indicate the relationship to be quite reasonable. This meant that it would probably not be possible to shift operating results so that the product would be on specs all the time. Hence the necessity of the upper initial boiling-point spec was examined, found to be unnecessary, and consequently removed. This permitted raising the initial boiling point to facilitate meeting the flash.

Results of Study

Figure 2 gives total results of the combined work. The upper graph shows an average daily production of 120 bbl./day during 1953, 80 during 1954, and a rather startling increase to almost 300 bbl./day as the results of the study were put into use by the plant members of the team. The sharp improvement in quality variation is also shown. Economic appraisal of these results indicates that teamwork on this small project alone increased the income of this refinery substantially.

Lube Stock Rerun Unit Case Study

In this example the group was asked to assist a refinery in operations planning involving a distillation unit in which lube stocks are made. At that time the problem had not been carefully formulated, and consequently the necessary data had not been collected. It is believed that the formulation of the problem, collection of the necessary information, and improvement of the information system, were definite contributions in themselves.

Table 2 illustrates the first phase in stating the problem. Six different operations, *A* through *F*, are most practical on this unit. Seven lube stocks, gas oil, 50 through 200 viscosity neutral oils, and bottoms are made on these operations. For each operation, varying yields of seven different products are obtained. For example, if operation *A* is run, 23% gas oil, 68% 100 viscosity oil, and 9% bottoms are obtained. Gas oil plus bottoms is called slop from each operation.

The next step in stating the problem is given in Table 3. Various data are given for each product considered. The minimum inventory (row 3) and the final inventory space (row 6) are determined on a probability basis by statistically measuring past sales forecasting errors. Currently the probability of running out, or over, for one product is set at one chance in 1,000. From these data it is desirable to determine the minimum and maximum amounts of each product that can be made during a coming month. These amounts will be used as limits on the production, or the flexibility in the monthly run. The minimum production (row 4) is the forecast sales (row 1), minus the inventory (row 2), plus the minimum inventory. The maximum production (bottom row) is equal to the tank capacity (row 5), minus the final inventory space (row 6), minus the inventory (row 2), plus the forecast sales. Thus, the minimum and maximum production figures are obtained from this table.

The problem is now one of determining how much of each of seven different cuts should be made from each of six different operating plans, within the production limits shown, so that the amount of slop material is minimized.

This problem is solved by a method known as the simplex method of linear programming. Table 4, giving the minimum slop operating plan and showing the amount of each product to be run in each plan, illustrates a typical result. Listed in the bottom row are the limiting directions of production restrictions. These indicate where the tankage is critical and where it could be advantageously shifted to further reduce the slop production. In other words the plan calls for the most 50 viscosity oil that can be made, and the least 75 and 100 viscosity oils. The other products are within the restrictions.

The general result of this work to date is that it appears to be a helpful guide to planning operations. In practice, minor considerations often arise which bring about minor changes in plans. An additional result to date is that the method has shown the importance of the forecasting error, since allowance for it severely restricts the operating plan. Emphasis at this time is on reducing forecasting error through development of a whole new system of prediction. Additional emphasis is also placed on checking and improving the yield data and establishing statistical control over the operations. These improvements will make the planning as realistic as possible.

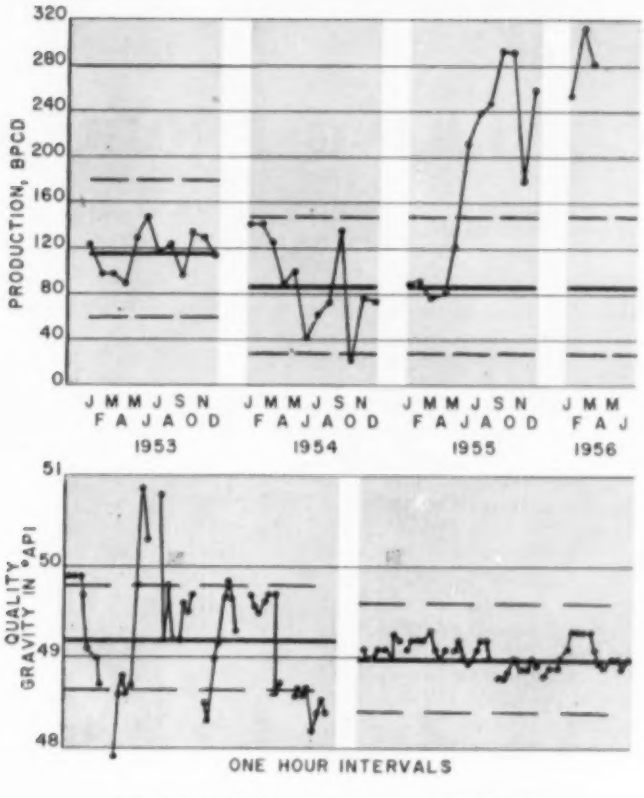

Fig. 2. Naphtha rerun unit. Varnolene production and quality.

Table 2.—Product Yields for Various Operating Plans

Operation	Slop *	Gas-oil	Products 50	75	100	150	200	Bottoms
A	.32	.23	...	...	.68	...	...	.09
B	.24	.14	...	.45	...	.31	...	.10
C	.22	.12	.32	...	.31	...	.15	.10
D	.16	.10	.26	...	.41	.17	...	.06
E	.20	.55	...	.44	...	.28	.08	.09
F	.47	.32	...	.25	...	.28	...	.15

* Slop = gas-oil + bottoms

Table 3.—Production Quantity Restrictions

		50	75	100	150	200
Forecast	F	3,250	5,500	22,000	1,500	2,000
Inventory	I	4,800	2,000	13,100	1,700	2,500
Minimum Inventory	MI	1,800	1,800	1,800	1,800	1,800
Minimum Production (MiP = F − I + MI)	MiP	250	5,300	10,700	1,600	1,300
Tank Capacity	TC	11,600	17,500	36,100	19,400	7,200
Final Inventory Space	FIS	1,800	1,800	1,800	1,800	1,800
Maximum Production (MaP = TC − FIS − I + F)	MaP	8,250	19,200	43,200	17,400	4,900

Table 4.—Production Table-Barrels to Be Produced

Operation	Slop *	Gas-oil	50	75	100	150	200	Bottoms
A	0	0	.....	.....	0	.....	.....	0
B	0	0	.....	0	.....	0	.....	0
C	2,648	1,436	3,839	.....	3,734	.....	1,851	1,192
D	2,720	1,686	4,407	.....	6,963	2,883	.....	1,034
E	2,409	1,325	.....	5,300	.....	3,373	964	1,084
F	0	0	.....	0	.....	0	.....	0
Totals	7,777	4,468	8,246	5,300	10,697	6,256	2,764	3,309
Restriction			max	min	min			

* Slop = gas-oil + bottoms.

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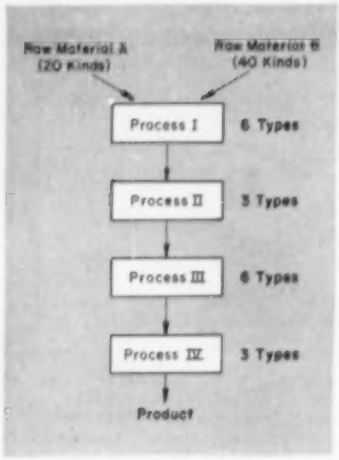

Fig. 1.

Research and

A SCHEDULING PROBLEM

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A problem common to those factory operations in which many products are manufactured on one machine is the concern of the accompanying article. It is desirable to study methods of arranging products for manufacture on such a machine in the most economical fashion. In an investigation of the problem, a close relationship can be found with other completely different problems, and it is possible to modify the mathematical approaches used on them and to devise a calculational procedure that leads to a solution of any particular case. The solution can give one the best schedule, with resultant significant savings in crew time, machine time, and materials.

In the manufacture of coated abrasive products, the Carborundum Company employs several large and expensive machines which perform several sequential operations on the product. Because of the large number of possible raw materials and processes, numerous products can be made, of which 2,000 are presently manufactured. In changing from product to product, both labor and lost materials constitute an expense, the size of which depends on the old and the new product. Change-over time has required more than half the available machine time.

At any one time, about 100 different products can be stated as requirements. The problem is to arrange these products in the sequence that will minimize change-over costs. It was found that the problem could be formulated as the "assignment" problem (*3*), which is a variation of the transportation (*1, 5*) and travelling salesman problem (*2*). Small scheduling problems can be solved by simple techniques, and larger ones by a variation of a routine that is adaptable both to manual and machine computation. Savings of $10,000 to $20,000 a year are expected.

Multiprocess Machine

In conformance with Carborundum's policy of supplying all abrasive requirements, the company makes a variety of coated abrasives, that is, sandpaper and abrasive cloth. Such material is made on rather large machines, the building costs of which approximate a million dollars. The machines are tended by a crew of about ten men and the machine reliability is high enough that breakdown is not a serious factor.

These machines are actually several machines in one, that is, each performs several immediately subsequent operations. For the purpose of illustration, each machine has been represented as performing four processes, each of which can be done in several different ways as shown in Figure 1. Adding to this the choice of the raw materials, here shown with twenty kinds of one and forty kinds of another, one arrives at an enormous number of possible products. This number, is in fact:

$$20 \times 40 \times 6 \times 3 \times 6 \times 3 = 259{,}200$$

and of these, about 2,000 are actually made. Even this is still a fairly large number. Each of these products differs from the others in one or more types of processes or raw materials used. What created the problem in question was this: in changing from one product to another, one raw material, one process or several of each of these must all be changed, and these change-overs were time consuming and costly. The change-overs amounted to about half the total machine time, and with several machines with large crews, the labor involved was in itself expensive. In addition, there were losses in start-up (that is, material which was run before the processes were adjusted) and losses of raw materials when these were changed. The total annual change-over cost, then, was something in excess of a quarter of a million dollars.

Generally, at a particular time there existed a list of, say, 100 products, with the quantities of each, that could be stated as requirements of the next manufacturing period and it was these that must be arranged in the best order. Serious thought of course had been given already to minimizing the change-over costs by experience and empirical methods, but without further analysis, it was impossible to tell how well that method of scheduling performed.

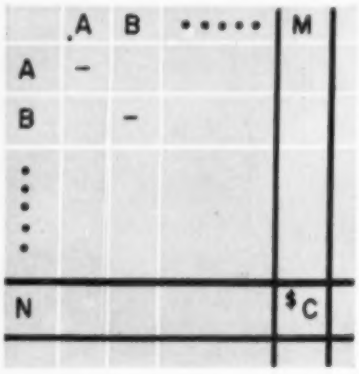

Fig. 2.

It turned out that the formulation of the problem suggested a solution. First the data were laid out in tabular form, as shown in Figure 2, where the quantity C includes the crew time, materials lost in start-up, raw materials lost when these are changed and any other costs that occur with this change-over from product m to product n. Notice that machine time is *not* included since this cost is fixed and would not enter until the machines were operating near saturation.

Such a table for all products would be large indeed—2,000 × 2,000, or four million entries. However, 100 products can be handled, and a table of this sort would have all 100 products at the top, and again at the side, and an entry would be the

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IN A MANUFACTURING PLANT

cost of changing from the product at the top to that listed at the side.

A small example of such a table is that shown in Figure 3. The circled entry indicates that a cost of seven units (which might mean \$70 or \$700) would be encountered in changing from product *D* to product *B*. The diagonal elements are forbidden since changes from one product to itself are not considered. In case one wished to minimize change-over *time*, say, the entries in this table would be hours or minutes, and the same procedure would be followed.

With a table like this, it is possible to evaluate the change-over costs of any particular sequence of manufacture, for example, to evaluate a sequence *A, C, B, D, F, E, A, C, B* . . . one would circle the entries *A* to *C*, *C* to *B*, *B* to *D*, and so on, as shown in Figure 4. The sum of the circled entries, which in this case is 27, would be the cost of continually making the products in the sequence given and repeating this sequence indefinitely.

It can be seen that a sequence like this requires that one entry and only one entry be chosen in each row and column, that is, each product goes to only one other (in this case *E* goes only to *A* and there is one entry in the *E* column), and each product is preceded by only one other (*B* is preceded by *C*, hence only one entry chosen in the *B* row).

If these products were not to be made continually in this sequence, that is, if the sequence were going to be run once and then another set of products scheduled, one must embellish this array slightly, by adding a "start" column and a "finish" row as shown in Figure 5. This column and row were added for completeness and may in many cases have equal entries as shown here, indicating that it costs no more to start or finish with one product than with another. Any particular sequence of manufacture can be evaluated as before and the cost of the schedule shown in the figure is twenty-four units. Again it can be seen that a valid sequence requires that only one entry be chosen in each row and column.

Since it is desired to minimize the change-over costs, and a valid sequence consists of one and only one entry in each row and each column, and the cost of a particular sequence is the sum of these chosen entries, it can be said now that the problem consists of choosing a set of entries such that their sum is least. In other words, in this particular array one might look for more attractive candidates than those chosen in the figure, such as the 1 occuring in column *A*, row *B*, the 1 occuring in column *A*, row *D*, the 2 occurring in column *D*, row *C*, and so on.

In the selection of such a minimum set, scheduling problems can be divided first into the smaller ones which can be done by inspection or by a trial-and-error process, and second those that need more refined techniques. The trial of the various combinations becomes tedious even for an array of this size, that is, 7×7, and there is one aid in selecting the best sequence. It can be proved that one can subtract from or add a constant to any row or column without changing the problem. For example, suppose that as much as

Fig. 3.

	A	B	C	D	E	F
A	–	10	4	7	9	4
B	1	–	2	(7)	7	5
C	4	10	–	2	5	9
D	1	3	10	–	3	2
E	5	3	3	8	–	2
F	10	3	10	7	4	–

Fig. 4.

	A	B	C	D	E	F
A	–	10	4	7	(9)	4
B	1	–	(2)	7	7	5
C	(4)	10	–	2	5	9
D	1	(3)	10	–	3	2
E	5	3	3	8	–	(2)
F	10	3	10	(7)	4	–

· · · A C B D F E A C · · ·

4+2+3+7+2+9 = 27

possible be subtracted from each column without creating any negative numbers, that is, subtract 1 from column *A*, 3 from column *B*, 2 from column *C*, and so on. Results are shown in Figure 6. Inspecting the rows reveals that nothing can be subtracted from any of them. Again, it is desired to choose minimum entries (0's if possible), one in each column and row. By considerable trial and error it is possible to find the sequence circled in this figure, which will cost sixteen units (as compared with twenty-four in the previous example), and is the minimum for this array. If it were not possible to obtain a valid sequence with the use of only zeros, one would use a minimum of the remaining entries that would work.

This sort of thing is only practical in small scheduling problems. It is possible to have problems with 100 products or 10,000 entries in a table such as this. These are not amenable to solution by inspection or trial and error and, in fact, one can get into serious difficulties in such an attempt. Problems of this sort have only recently approached solution, and they are found in the literature under the name of "Transportation," which is a simpler case of the general linear programming problem, and "Travelling Salesman" problems and "Assignment" problems, which are in turn a simpler case of the Transportation. An orderly selection routine has been developed by H. W. Kuhn (*4*). Although the "Hungarian Method" is simple, it will be covered only briefly here.

The Hungarian Method

The method given in Kuhn's article contains a routine of six or seven simple steps each of which involves at most addition. This routine is applied over and over again, and each application brings one measurable closer to the solution. The steps have been modified somewhat to fit this particular problem. When it is necessary to do these problems by hand, it takes one man in the neighborhood of one to two weeks to work out such a solution for 100 products once all the data are available to him. Since 100 products require one month to run, it is possible to keep up with the operation. The method given in Kuhn's example solves the *assignment* problem whereas the problem at hand is a more complicated case of the travelling salesman. The solution to the assignment problem does give, however, a set of shorter schedules that can be combined into a nearly optimum complete schedule.

Because of the large amount of time required, manual scheduling is not very practical for most large problems. It is possible to propose alternatives to continuing manual scheduling.

1. The solution to several problems will reveal any general principles that ought to be followed in scheduling and the application of these principles to the day-to-day scheduling may bring one so close to the optimum that further refinement is not necessary.
2. The method of handling large schedules is fairly adaptable to large-scale digital calculating machinery to the extent that one could present to the computer only a list of the products to be manufactured and within one to two hours of computer time one would receive a set of optimum and near-optimum schedules.

Dollar savings to the company in question have only been estimated. Previous studies in the travelling salesman problem have indicated savings of about 30% by use of these techniques. A 13% reduction in scheduling costs has been demonstrated and can be reasonably expected in the future. This amounts to some $32,000 a year. Further, the productivity of the machines will have been increased by this same percentage. With the increasing demands, this may make unnecessary in the near future the purchase of additional machines at a price of more than one million dollars.

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Presented at A.I.Ch.E. meeting, Pittsburgh, Pennsylvania.

Fig. 5.

	A	B	C	D	E	F	Start
A	–	10	4	7	9	4	(3)
B	1	–	(2)	7	7	5	3
C	(4)	10	–	2	5	9	3
D	1	(3)	10	–	3	2	3
E	5	3	3	8	–	(2)	3
F	10	3	10	(7)	4	–	3
Finish	3	3	3	3	(3)	3	–

Start A C B D F E Stop
3+4+2+3+7+2+3=24

Fig. 6.

	A	B	C	D	E	F	Start
A	–	7	2	5	6	2	(0)
B	0	–	(0)	5	4	3	0
C	3	7	–	(0)	2	7	0
D	(0)	0	8	–	0	0	0
E	4	0	1	6	–	(0)	0
F	9	(0)	8	5	1	–	0
Finish	2	0	1	1	(0)	1	–
	-1	-3	-2	-2	-3	-2	-3 = -16

Here is a straightforward account of how Operations Research methods and techniques are gradually being introduced at the Texas Division of the Dow Chemical Company. These actual case studies should be of extreme interest to every chemical engineer who has been wondering about the possible application of this new analytical tool to the problems of his own company.

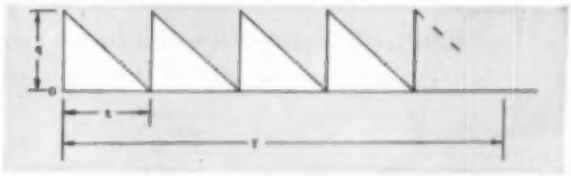


Fig. 1.

Case studies in OPERATIONS RESEARCH

Joseph Rio and A. F. Shorkey | Dow Chemical Company, Freeport, Texas

The "whole systems" approach has not yet been adopted at the Texas Division of the Dow Chemical Company. The authors, who studied Operations Research methods at Case and M.I.T., believe that much can be accomplished on a smaller scale in the sense that one must learn to creep before walking or running. The following four cases are examples of approaches which have been carried out at Dow. They range from the fairly simple concept of probability and the place it should have in our thinking to the more complex Monte Carlo and Inventory Models. The authors are convinced that, once the method has proved its worth to management, their effort will be expanded to include system-wide examinations.

Case 1

This case originally started out as an application of the light-bulb-replacement type problem. It involved some fairly expensive cast iron batch reaction vessels. Failure of these vessels generally resulted in extensive damage to the supporting structure. In view of the large cost associated with failure, it was desired to determine an optimum time for replacing the equipment; this determination would minimize the sum of the breakage and the resulting expenses. The life distribution curve for the equipment was approximately normal and had a standard deviation which, on a time basis, was very large. However, in terms of the light-bulb-replacement approach, an optimum time for replacement was estimated. This optimum time was found to be of negligible practical value in view of the ratio of new equipment and failure costs and because a rather small fraction of equipment remained after the optimum time.

In an analysis of the data on equipment failure distribution, it became readily apparent that one of the more serious aspects of the problem concerned the timing of the replacements. Because the failure distribution was so wide, failures had been considered to occur in an extremely erratic and unpredictable fashion. No matter how carefully replacement ordering was done, the new vessel inventory pattern always presented a feast or famine aspect. This was especially true if the sales pattern changed drastically.

Breakage is a function of cycles and thus of throughput. However, in a probability sense the failure pattern seemed quite definite rather than erratic; hence, an attempt was made to predict the number of failures that would occur in some definite time unit, such as a month. It was intended that replacements would be scheduled then in anticipation of these predicted failures.

Since the starting point in the lives of the equipment varied from one piece of equipment to the next, no simple analytical approach was available for making these predictions; therefore the Monte Carlo technique was adopted, in terms of which the following approach was used.

1. Each reaction vessel was listed with its usage up to some definite date.
2. A number from the same distribution as the failure distribution was selected at random and applied to each reactor.

If the number was larger than the existing life, the difference between the random number chosen and the usage represented an estimate of how much more service would be obtained from that particular piece of equipment before failure. If the number was smaller, it would be rejected and a new number selected. The extra capacity before failure estimated as above was converted to a time basis; production rate was taken into consideration in the conversion. This process of random number selection was repeated for each piece of equipment in turn, and then for all pieces of equipment, each taken individually a number of times.

Time-of-failure data computed by this Monte Carlo technique gave an expected failure distribution for the coming months. For example, the expected number of failures for the next month might be two with a variance such that one could reasonably expect one to three failures, and so on for ensuing months. An ordering system based on these predicted failures was set up. Equipment was scheduled to arrive before these failures occurred so that replacements were immediately available. At the same time, this procedure maintained an optimum dollar-value inventory of new vessels. Prices from the manufacturer were reduced because now he had a year's pattern on which to schedule his own production. Comparison of predicted and actual failures covering a period of about one year agrees well within the limits of error of the data generated by the Monte Carlo approach.

The case just discussed by no means represents a complete Operations Re-

A. F. Shorkey is superintendent of Alkali Products.

Table 1.—Cost Estimates for Various Program Combinations Designed to Increase Plant Production

Increased sales value equivalent to $150,000/month at completion of successful program. Coded Data.

Program combinations	Probability of success in obtaining desired extra capacity P_1	Time required to install and test program N_1	Total delay if program fails	Probability of failure of program to obtain desired capacity $(1 - p_1)$	Program equipment cost C_1	Value of lost production N_1L_1	Value contributed to next program	Calculation of probable cost $= C_1 + N_1L_1 + (1 - p_1)(C_2 + N_2L_2)$ (see below for definition of terms)	
1	0	0	..	1.00	0	$150,000/mo.	0		= $150,000/mo.
5	.99	6	6	.01	$675,000	$900,000 total		$675,000 + 900,000	= $1,575,000 total
2	.25	5		0.75	100,000	750,000	0		
5	.99	6	11	.01	675,000	900,000	.....	100,000 + 750,000 + .75(675,000 + 900,000)	= 2,030,000
3	.25	6		0.75	125,000	900,000	$170,000		
5	.99	6	12	.01	675,000	900,000	.....	125,000 + 900,000 + .75(505,000 + 900,000)	= 2,078,000
4	.7	7	13	0.3	180,000	1,050,000	170,000		
5	.99	6		.01	675,000	900,000		180,000 + 1,050,000 + .3(505,000 + 900,000)	= 1,696,000

C_1 = equipment cost of first program of combination
N_1 = number of months to install and test first program
L_1 = value of lost sales per month during first program
p_1 = probability of success for first of program combinations
$(1 - p_1)$ = probability of failures of first of program combinations
C_2 = equipment cost of second program of combination, that is, the cost of second program less value contributed by prior program
N_2 = number of months to install and test second program
L_2 = value of lost sales per month during second program

PROGRAM DEFINITIONS:

1. Do nothing and operate at existing capacity.
2. Modify existing reactors by making change *A*.
3. Modify existing reactors by making change *B*.
4. Modify existing reactors by making change *C*.
5. Add additional process equipment.
6. The value contributed to next program is represented by a decrease in scope of second program to the extent shown. This is result of some increase in capacity as a result of modifications.

search job. However, it points rather nicely to new areas that need to be, and are being, investigated. For example, the desire is to determine what the optimum equipment inventory should be in relation to company financial practices, sales predictions, vs. actual sales, and company policy on production inventory. This question of production inventory brings into the picture the optimizing of production scheduling. Also it is necessary to know something more about the vendor's shipment pattern after orders are placed. This one item has, in the past, come close to causing serious shortages in replacements.

Case 2

This case can be characterized as a "quick and dirty" method of making a process change. The nature of the problem was this: an operating plant could not produce enough to meet the new sales demand. Increased capacities were possible if sufficient time was available to develop various methods of improving the existing equipment. A quick change could be effected by purchasing additional equipment. Such a step, however, might have resulted eventually in more capacity than needed. The cost of lost sales was estimated and found to be quite high; for this reason the time available for deciding what to do was rather short. The rather simple approach used has been found satisfactory to date.

First the probability of obtaining the desired extra capacity by modifications in the existing equipment was estimated together with the time factors involved. Second the probability of obtaining the desired extra capacity with new equipment was estimated. Third the expected cost of these two alternatives was compared, including lost sales, up to the moment at which the new equipment would be operating.

From a comparison with the near certainty of success by an immediate large capital expenditure, it was quite obvious that a great deal of money could be lost in terms of sales if one of the various alternatives for improving the existing equipment capacity were adopted and did not materialize in the time required. Consequently, the additional new equipment was ordered. The new equipment is still in the process of being installed, and development work in connection with increasing the existing production capacities has continued with some improvement in output. However, to date, the extra capacities obtained with existing equipment have been short of the desired capacity to approximate the extent predicted. This has justified the probability value used in estimating the likelihood of obtaining the desired capacity with modifications in the existing facilities in the time required. Also this development work has strengthened the probability estimate made for the ability of the new equipment to meet the desired production capacity increase. By the use of this approach in choosing one of the several alternatives, it is estimated that several months have been saved and probably several hundred thousand dollars. (See Table 1.)

Case 3

The problem here is a typical one. A raw material was being inventoried. Because of the high potential cost of possible shortages, a liberal inventory policy was being practiced. However, it was thought that some reductions in inventory could be made safely. Consequently, the problem of making inventory of this raw material was approached in a series of steps. As a first approach the simplest of all inventory models was used. The assumptions here are that the inventory is increased instantaneously from zero up to the optimum level, that the usage rate is constant, and that, when zero inventory level is reached, the inventory is brought immediately up to the optimum inventory again. In this model, amounts ordered and time between orders are constant. The solution in terms of expected optimum costs, ordering amount, and frequency of ordering are well known. What is

done, of course, is to balance the cost of the money tied up by the average inventory against the cost of ordering. Solution of this inventory problem in terms of this simple model indicated that existing inventory levels were quite high.

To be realistic, the model had to be modified to resemble the existing situation closely. Modification involved the inclusion of a usage variance, a delivery variance, and the possibility of strikes in suppliers' plants. Addition of the variances due to varying usage and to early and late delivery of raw material indicated that the existing inventory policy was still liberal and that it could be cut to approximately one-half the nominal minmum in current use without any danger of shortages. Also, a check in terms of reliability of delivery showed that shortages of raw material supplies due to strikes were rather unlikely because of the existence of multiple suppliers and of multiple plants owned by each supplier.

A solution which was acceptable to the operating plants was recommended and was adopted by them. This solution, which was somewhat less than an optimum one, was tentatively recommended at about one-half the former level normally maintained as a minimum level. Changes in the ordering pattern were also involved.

The following models illustrate the approach used in studying inventory problems for Case 3:

MODEL 1

Uniform usage rate, equal time intervals between receipts of inventoried material, no shortage allowed. (See Figure 1.)

q = ordering amount
q_o = optimum amount to order
t = time between orders
t_o = optimum time between orders
T = total time period
R = requirements in time period T
C_1 = cost of ordering one shipment of inventoried item
C_2 = cost of inventorying one unit of inventoried item for one unit of time at interest rate i
$q/2$ = average inventory over time T
TEC = total expected cost
subscript o refers to optimum value

$$TEC = C_1 \frac{R}{q} + C_2 \frac{q}{2} T =$$

total expected cost of inventory policy over time period T

$$\frac{\partial(TEC)}{\partial q} = -C_1 \frac{R}{q^2} + \frac{C_2}{2}(T)$$

$$= 0 \text{ at optimum } q$$

$$q_o = \sqrt{\frac{2C_1R}{TC_2}} \qquad t_o = \frac{Tq_o}{R}$$

$$= \sqrt{\frac{2C_1T}{C_2R}}$$

$$TEC_o = C_1 \frac{R}{q_o} + C_2 \frac{q_o}{2} T = \sqrt{2C_1C_2RT}$$

Specifying ordering amount q_o, time between receipts, t_o, is called an inventory policy, and in this case since q_o and t_o are specified, the total expected cost is optimum at TEC_o.

MODEL 2

Same as Model 1 except usage rate varies in some stable distribution pattern, say, a normal distribution, and shortages are allowed. Time between shipment receipts may vary, but amounts received are constant. (See Figure 2.)

C_3 is the cost of shortage per unit of inventoried item. Model 2 can be represented as shown in Figure 3, where $\bar{q}_o$ and $\bar{t}_o$ refer respectively to the optimum average amount of inventoried material used in an optimum average time period $\bar{t}_o$, and where $\bar{q}_o$ and $\bar{t}_o$ are determined by the use of

OPERATIONS RESEARCH

Model 1. The distribution area below the zero inventory line represents the fraction of times that shortages would occur if each inventory period started at $\bar{q}_o$. By changing the period starting inventory to $\bar{q}_o + q_1$, so that the ratio of areas above and below the zero inventory line is such that the shortage cost C_3 is equal to the added inventorying cost associated with q_1 extra inventory, a new optimum inventory policy is obtained. This optimum inventory policy is optimum relative to the varying usage rate, to the cost of shortages resulting from varying usage rate, and to the cost of ordering. This model is shown in Figure 4.

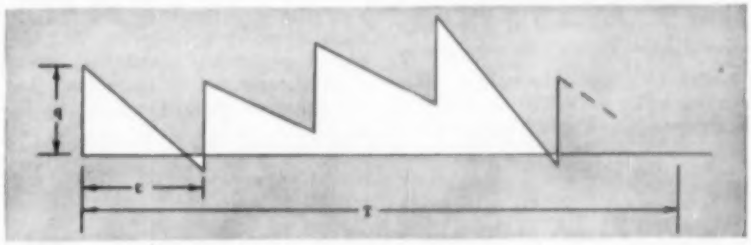


Fig. 2.

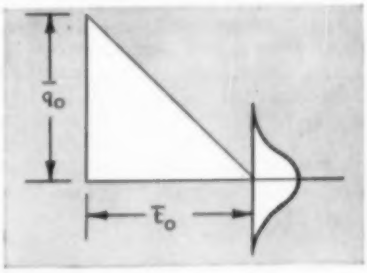


Fig. 3.

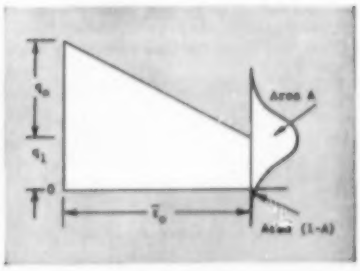


Fig. 4.

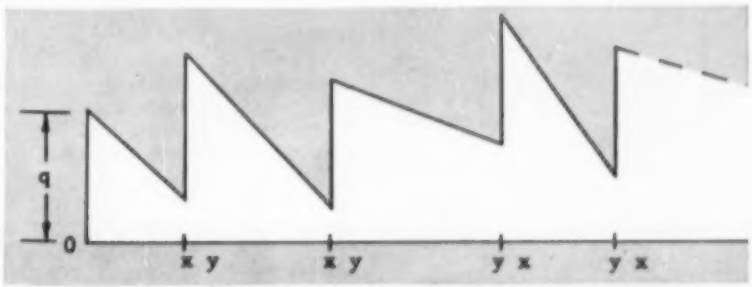


Fig. 5.

In the case above, $(1\text{-}A)C_3 = q_1C_2T$ at the optimum, that is, one can afford to pay for the inventorying of extra amount q_1 to avoid the shortages associated with $(1\text{-}A)$, but if we pay more than this, the extra inventorying costs will exceed the savings in shortage costs, and if we pay less than this, the extra shortage cost will be larger than the reduction in inventorying costs.

Analysis of this model requires modification in that the periods starting inventory will not always be $\bar{q}_o + q_1$ with a fixed time between delivery, due to varying usage rates and to the dependence of the new periods starting inventory on how much remains from the previous inventorying period. This modification can be introduced by placing an order timed so that, if the average usage rate occurred, the inventory on the next delivery would be $\bar{q}_o + q_1$. The time between deliveries then would vary and would depend directly on the usage variance, but the average time between deliveries would still be $\bar{t}_o$.

An alternative solution might be to order varying amounts at fixed time interval $t_o (= t)$, so that on delivery the inventory would be $\bar{q}_o + q_1$. Use of either of these alternatives will prevent the tendency of the inventory to "walk away" from optimum and these alternatives constitute a control on inventory.

MODEL 3

Same as Model 2, except that there is a delivery variance, that is, delivery of inventoried material does not occur necessarily on date specified, but rather forms a distribution pattern around the specified delivery date. (See Figure 5.)

The effect of the added delivery variance (Figure 6) is to broaden the distribution pattern of Model 2, that is, to increase the probability of the existence of shortages. The resulting larger area under the zero inventory line must be compensated for by increasing the target inventory of Model 2 from $\bar{q}_o + q_1$, to $\bar{q}_o + q_1 + q_2$, where inventory cost for $q_1 + q_2$ equals the shortage costs.

By continued summation of other inventory variances we would obtain $\bar{q}_o + q_1 + q_2 + q_3 + q_4 + \ldots$, where each of the quantities q_1, q_2, q_3, etc., would have an inventory cost at optimum inventory equal to the shortage cost where each q quantity of inventory is generated to compensate for the existence of variances, v_1, v_2, v_3, v_4, ...

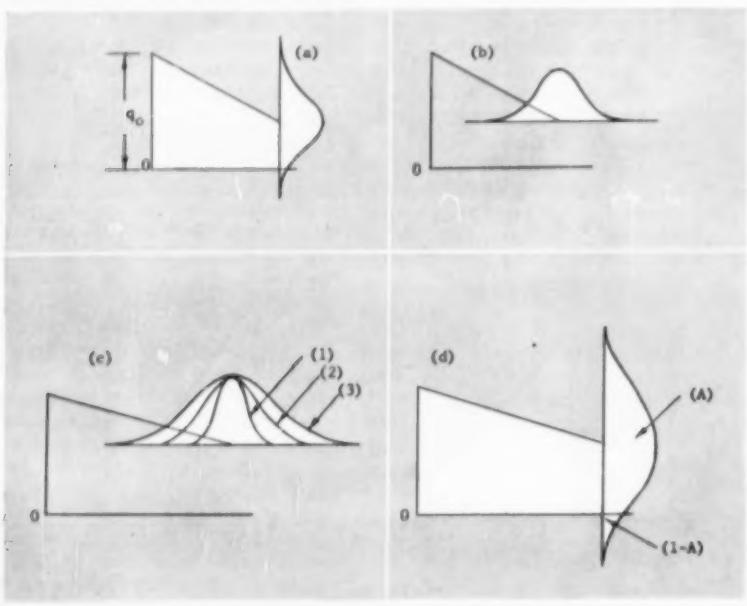
Fig. 6. Explanation of diagrams (a)-(d).

Diagram (a): Model 2 with distribution of usage placed so as to optimize inventory relative to ordering and inventory costs, and to usage variance.

Diagram (b): Same as (a) but distribution has been rotated 90 degrees and converted from quantity basis to time basis with the average rate of use per unit time for conversion.

Diagram (c): Same as (b) with delivery variance (1) shown and added to usage variance (2) to obtain sum of usage and delivery variance (3).

Diagram (d): Same as (c), showing only sum of usage and delivery variances rotated 90 degrees, and converted back to quantity basis.



Case 4

Analysis frequency of routine shipments: all shipments of a product were analyzed and customer charges made on the basis of the analyses. The analysis costs were felt to be rather high. On the other hand, it was felt necessary to analyze all shipments since sales were charged on the basis of the analyses. Tied in with this was the fact that shipments were made with specifications on the impurities present. It was desired to optimize the shipment analysis costs.

The analysis frequency distributions obtained on the shipped production were such that it was evident small but important changes in the process occurred, since multimodal distributions were obtained. It was evident from analyses of the distribution of data within each day that the within-day variation in the properties of the product was rather small and therefore analyses of the first shipment per day would be adequate for the purpose of charging the customer. However, it also was evident from examination of the first shipment per day data that the first sample analysis would not be adequate to assure meeting customer specifications for subsequent shipments during the day even though the first sample was itself within specifications. Therefore, the first part of the problem of optimum shipment costs involved a quality control program to eliminate the multimodes from the process data. This was done and a quality control program installed to maintain a close surveillance on specifications. Subsequent analysis of the new distribution of data obtained after the quality-control program was installed indicated that it would be feasible to reduce the shipment analysis frequency.

Examination of the distribution on which the charges for material shipped was made showed that the new analysis variance was considerably reduced, and that an analysis scheme based on analyzing the first shipment each day would result in charges made to the same customers for subsequent shipments during the day that would have negligible deviations from the charges based on the actual analyses for subsequent shipments on the same day. In any case the negligibly small deviation of these charges from the "true" charges would average out rapidly over a few shipments so that neither the company nor the customer would receive more than was fairly due.

Presented at A.I.Ch.E. meeting, Pittsburgh, Pennsylvania.

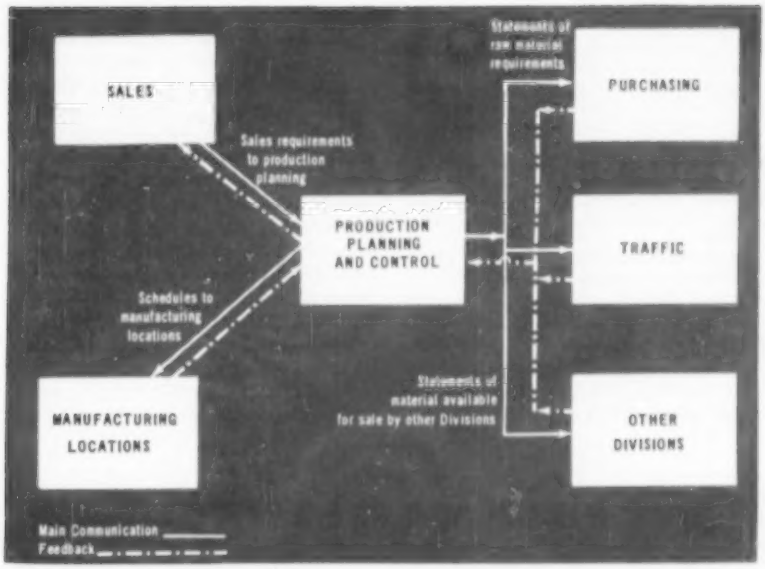


Fig. 1. Communications flow diagram.

PRODUCTION PLANNING

—— an Opsearch case study

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Production planning has been under study at Monsanto's Organic Chemicals Division for the past three years with the objectives of reduced manufacturing costs, improved customer service, proper inventory control, and a more uniform work force at the manufacturing locations. Some important results have been obtained in each of these areas. Thirteen separate manufacturing locations, producing more than 500 chemical products in more than 1,000 different grades, are involved. The case history discussed in the accompanying article deals with the establishment of a centralized production planning and control group and with the development of improved production scheduling techniques.

Production planning is not new to industry, to Monsanto, or to its Organic Chemicals Division. It is necessarily a constant companion to production. Its methods and organization can be expected to change to correspond with changes in production technology, product line, company organization, financial circumstances, company growth, and other factors. Organization and methods that were adequate five years ago may not be fully satisfactory today. Need for improvement in the production planning methods was recognized in late 1953.

At that time, an intensive study was made of the division's manufacturing organization. The functions and major areas of manufacturing activity were identified and grouped into logical units. The existing organization was assessed in terms of the desired objectives, and a change was found necessary. An operations research approach of defining and working for a solution of the total problem was used. Production planning was one part of the total problem studied.

Up to this time, production planning had been an individual plant responsibility. The mechanics of handling the duties varied according to plant size. At the larger plants the planning function was assigned to a full-time production coordinator and his staff; at the smaller plants it was handled by line supervision. Periodically these arrangements were modified and augmented in an effort to keep pace with the growth of the division. However, a comprehensive study of the existing organization showed that it was not adequate to do the job assigned. Limitations, in varying degrees, were noted in the following major areas:

1. communications between sales and manufacturing.

2. translation of sales requirements into production schedules.
3. integration of production among plants. (It is not uncommon for the various reaction steps of a finished material to be carried out at three or four different plants. In addition, many products are produced at two or more locations.)
4. inventory control and inventory level justification.
5. short- and long-range forecasts of raw material requirements and summaries of forecasts.
6. production scheduling for minimum costs.
7. efficiency of scheduling techniques.

The study further indicated that these responsibilities should be centralized in a division-level staff group. It was concluded that no organizational arrangement based on plant responsibility for production planning could be expected to do as adequate a job as a central group. (This should not be construed to mean that centralized production planning is necessarily always the best arrangement in multiplant manufacturing. Production planning organizations must depend upon the particular responsibilities assigned and on the complexities of manufacture.)

The Monsanto study in 1953 led to the establishment early in 1954 of a Production Planning and Control section, a staff group under the director of manufacturing. The new central group assumed the production planning function previously handled separately by the plants, plus a number of new responsibilities.

Realignment of communications to conform with the new organization became the first order of business. The pattern developed is shown in Figure 1. Handling of sales requirements is used to illustrate the flow of communications. Sales requirements in the new system are furnished to Production Planning and Control where they are translated into (1) production schedules for each manufacturing location, (2) statements of raw material requirements for the Purchasing and Traffic department, and (3) statements of material available for sales by other divisions within Monsanto.

A marked improvement in communications was obtained through this centralized production planning arrangement. Although better communications were expected when the division-level organization was established, the full extent and import of the improvement was not foreseen at that time. Experience has shown that improvement in communications through centralized production planning represents a major contribution to the division.

Current Methods of Scheduling Production

The primary responsibility of the Production Planning and Control group is to provide the manufacturing locations with schedules which specify quantity and timing of production. Production scheduling begins with the receipt of a quarterly sales forecast from the Sales department. This is a twelve-month forecast for all products offered by Sales. It gives firm estimates for the coming quarter and tentative estimates for the other nine months. Based on these sales forecasts, a twelve-month forward production plan is prepared and published quarterly. This plan is the general schedule under which material will be produced for the next year but may be revised at any time on the basis of plant experience or change in sales requirements. A two-month segment of a typical plan is shown in Table 1. The definitions below describe the terms used in this table.

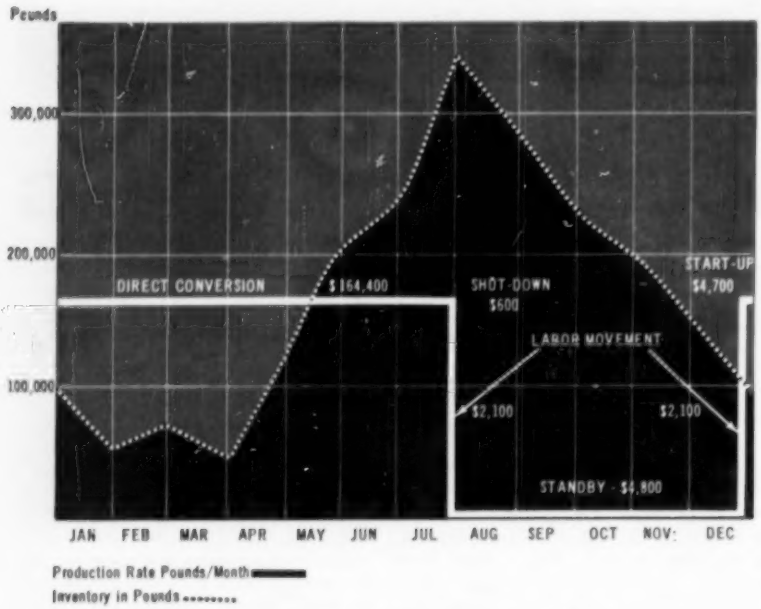

Fig. 2. Case I—alternate manufacturing schedule for an agricultural chemical.

Table 1.—A Two-month Segment of a Typical Twelve-month Forward Production Plan.

Product *XYZ* Capacity 250,000 lb./month
Minimum inventory 100,000 lb.

	January lb.	February lb.
Inventory—first of month	210,000	125,000
Production	250,000	225,000
Purchase	0	0
Total available	460,000	350,000
Use for A	40,000	40,000
B	60,000	0
C	75,000	70,000
Sales	160,000	130,000
Total requirements	335,000	240,000
Inventory—end of month	125,000	110,000
Inventory—end of month	$44,000	$38,000
	lb.	lb.
Raw materials M	180,000	162,000
N	112,000	101,000
O	37,000	34,000
P	30,000	27,000
Q	17,000	16,000
Operating labor (number of men)	21.0	21.0

- *Minimum inventory*
  The minimum inventory for sales must be maintained at all times. A minimum inventory has been established by mutual agreement between Sales, Manufacturing, and Business Research for each product and for each grade of product that is carried in stock.

- *Production*
  This is the instruction to the plant to produce the indicated quantity during the month specified.

- *Use*
  There are a large number of "family trees" where one finished product is the raw material for another product, which in turn is the raw material for a third finished product. Finished product *XYZ* is a raw material for finished products *A*, *B*, and *C*.

- *Raw materials*
  M, *N*, *O*, *P*, and *Q* are raw materials for *XYZ*.

Data from the basic twelve-month plan are converted to the "finished plan" by the IBM-702, an electronic data processing machine. It prepares the final plan for each product and summarizes raw material requirements, operating personnel requirements, and the value of month-ending inventory by manufacturing sites and in total for the division. The data processing ability of the IBM-702 has permitted for the first time rapid and economical preparation of these comprehensive summaries. A forward statement of raw material requirements is furnished to the Purchasing and Traffic Department; availability of this information has permitted improved purchasing strategy and achieved significant savings in purchasing costs and transportation charges. Operating personnel requirements are accumulated into a twelve-month forward estimate of total hourly employment at each plant. This is used as one measure of the merit of the production plan. If there are wide variations in labor requirements, the plan is revised where possible to give minimum fluctuations in employment. The inventory data provide another measure of the merit of the plan; it is used in budgeting and inventory control. The production plan is reviewed and changed as necessary if the inventories appear to be outside acceptable limits.

At the present time, the basic production plan is manually prepared based on experienced judgment for most products. Some products are scheduled from optimum cost calculations. There is little difficulty, of course, in scheduling production in single-use equipment where requirements are essentially equal to capacity; the department is simply scheduled to produce at capacity. However, there is an obligation to employ an operations research technique in scheduling production in single-use equipment when requirements are sufficiently less than capacity so that alternate schedules of manufacture are possible. In these cases schedules should be prepared on the basis of minimum costs.

Table 2.—Comparison of Controllable Costs for Two Alternate Manufacturing Schedules for a Particular Agricultural Chemical

	Case I	Case II
Direct conversion expense for production of 1,145,000 lb.	$164,400	$173,000
Shut-down cost	600	0
Labor movement—shut-down	2,100	0
Standby expense	4,800	0
Start-up cost	4,700	0
Labor movement—start-up	2,100	0
Labor movement—first reduction	0	800
Labor movement—second reduction	0	400
Labor movement—rate increase	0	1,200
Inventory carrying cost @ 20%	23,700	9,900
Total controllable cost	$202,400	$185,300
Savings		$17,100

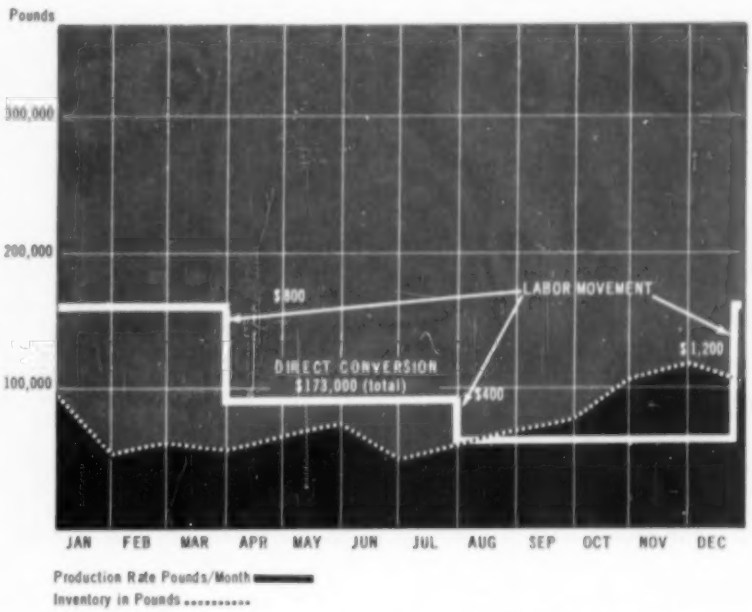

Fig. 3. Case II—alternate manufacturing schedule for an agricultural chemical.

OPERATIONS RESEARCH

Improvements in Scheduling Techniques

The eventual goal of the current work on improving production planning techniques is (1) to optimize the over-all divisional production plan (that is, to make the required amount of production at lowest total cost), and (2) to be able to prepare a complete optimum plan at any time as required by changing sales estimates. This problem is being approached from the point of view of the director of manufacturing—minimum total manufacturing cost—rather than from the general manager's viewpoint—maximum gross profits. This approach is necessary since Production Planning is a staff group under the director of manufacturing and has no control over selling prices and only partial control over the product line.

Initial work disclosed that existing information was not adequate to permit either postulating all possible alternate methods of manufacture or calculating their associated costs. Possible production rates were only partially identified. (Variations in rates are possible by changing the time operated—five-day week, two or three shifts a day; a seven-day week, two or three shifts a day—and, also, occasionally by changing the number of personnel.) The available cost information was essentially limited to sustained operating conditions for a few of the possible production rates.

In order to determine the necessary production rates and cost information, an Operations Research team was established at each large plant to perform cost analysis studies. The following were identified for each product:

1. all appropriate levels of operation and associated standard manufacturing costs
2. shutdown expenses
3. start-up expenses
4. stand-by costs
5. costs of labor movement
6. change-over expenses for multipurpose equipment.

The Operations Research team was headed by a full-time chairman who had substantial production experience (more than 15 years), and included a representative from the plant Personnel, Production Planning, and Accounting departments. These teams developed most of this information within seven months.

Two examples will demonstrate how an "optimum" schedule for an individual product is determined.

Model for Evaluating Alternate Production Schedules

Annual sales and captive-use requirements for a particular agricultural chemical are 1,145,000 lb. (95,500 lb./month avg.). Annual production capacity is 1,920,000 lb. (160,000 lb./month). This is single-use equipment. The problem is to establish how operations can be scheduled to make these requirements at lowest total cost.

One alternative is to operate at capacity until requirements are produced and then to shut down for the remainder of the year. In addition, since this department can be operated at several production rates below full capacity, several other alternate schedules are possible. The decision on which alternate schedule to select is based on a comparison of controllable costs for each schedule. Possible production levels are 160,000; 120,000; 90,000; 60,000; and 0 lb./month.

Twelve alternate schedules were postulated, two of which are illustrated in Figures 2 and 3. Case I (Figure 2) describes manufacture at capacity followed by a shutdown. Case II (Figure 3) shows manufacture by one combination of various production rates with no shutdown involved. The controllable costs are compared in Table 2. The difference in cost is a saving of $17,100 by producing at the Case II schedule compared to Case I. It is interesting to note that Case I, which had been the normal way of operating this department and which had been intuitively assumed to be the most economical schedule, was the most expensive of the twelve cases considered. Case II was the least expensive.

The evaluation of how to schedule this agricultural chemical was done manually with the aid of a desk calculator. Once the cost-production levels-requirement information was available, the mechanics of postulating and calculating the costs of the twelve alternate schedules required about 12 hr. The manual handling of this problem displays certain limitations which are likely to be typical of most products where requirements are for less than 70-80% of capacity. Some of these limiting factors might be:

1. Although twelve schedules were postulated and evaluated, there is no assurance that a better schedule could not be found.
2. Time requirements are substantial. (It is not practical to handle the entire Organic Chemicals Division plan in this detailed manner.)
3. Sales or captive-use requirements may change significantly at any time which would require a complete reworking of the problem.

Use of the IBM-702 to prepare a complete optimum production plan for the Division has been under study for several months. Initial work has been limited to considerations of optimum schedules for individual products, and the IBM-702 has already been programmed to prepare and evaluate several specific schedules by following essentially the same steps that are required manually. Anticipated use of the IBM-702 includes optimization of the individual product schedules, the production plan for each manufacturing location, and the over-all plan for the Division. Work is planned to follow in this order.

Model for Optimum Length of Run—Intermittent Operations

The second example involves the use of an optimum length of run calculation. Requirements of 127,000 lb./month of a complex organic chemical are 64% of capacity. Because of processing techniques, this product must be made at maximum rate. Obviously a shutdown of some duration is necessary, hence the problem is to determine the optimum length of run. This can be calculated from a method developed as follows:

C = cost in dollars per pound of any production run of W pounds
Co = cost of sustained operations
A = shut-down and start-up expenses
I = average inventory, lb.
R = monthly cost of carrying inventory
P = production rate, lb./month
S = sales rate, lb./month
D = duration of the sales and captive-use cycle in months numerically equal to W/S
W = production run in pounds

The average inventory, (I), will be the amount of material produced during the run minus the amount sold during the production period, divided by 2:

$$I = \frac{\left(W - \frac{WS}{P}\right)}{2} = \frac{W}{2}\left(1 - \frac{S}{P}\right) \qquad (1)$$

If the assumption is made that inventories will be valued at Co, the over-all average cost per pound becomes:

$$C = Co + \frac{A}{W} + \frac{(I)(Co)(R)(D)}{W} \qquad (2)$$

Combining Equations (1) and (2), simplifying, differentiating with respect to W, and setting the differential equal to zero to minimize the function gives:

$$W = \sqrt{\frac{2APS}{(P-S)CoR}} \qquad (3)$$

Equation (3) thus gives W in pounds corresponding to the optimum size run having the lowest over-all cost.

By applying Equation (3) to the organic chemical in this example, the optimum length of run is shown to be 1,400,000 lb. This is equivalent to capacity operation for seven months. The factors required by Equation (3) and the calculation are shown below:

Co = $0.56/lb.
A = $26,650
P = 200,000 lb./month
S = 127,000 lb./month
R = 20%/yr. = 0.0167/month

$$W = \sqrt{\frac{2(26{,}650)(200{,}000)(127{,}000)}{(73{,}000)(0.56)(0.0167)}}$$

W = 1,400,000 lb.

Other Scheduling Problems

In addition to the two examples cited, the following types of operations or scheduling problems must be considered and are under study:

1. Scheduling of multipurpose equipment under conditions of full and partial occupancy.
2. Outside purchase vs. manufacture of any product or group of products.
3. Contracting manufacture to outside company vs. manufacture in own equipment for any product or group of products.
4. Purchase vs. manufacture of raw materials.
5. Scheduling of new or developmental products.
6. Integration of operations where the same product can be made in two or more locations.

Acknowledgment

R. M. Morris, director of manufacturing, Organic Chemicals Division, conducted the manufacturing audit, and conceived and established the production planning organization described in this article. The method of determining the optimum length of run for intermittent operations was developed by R. E. Howard, assistant director of research, Organic Chemicals Division.

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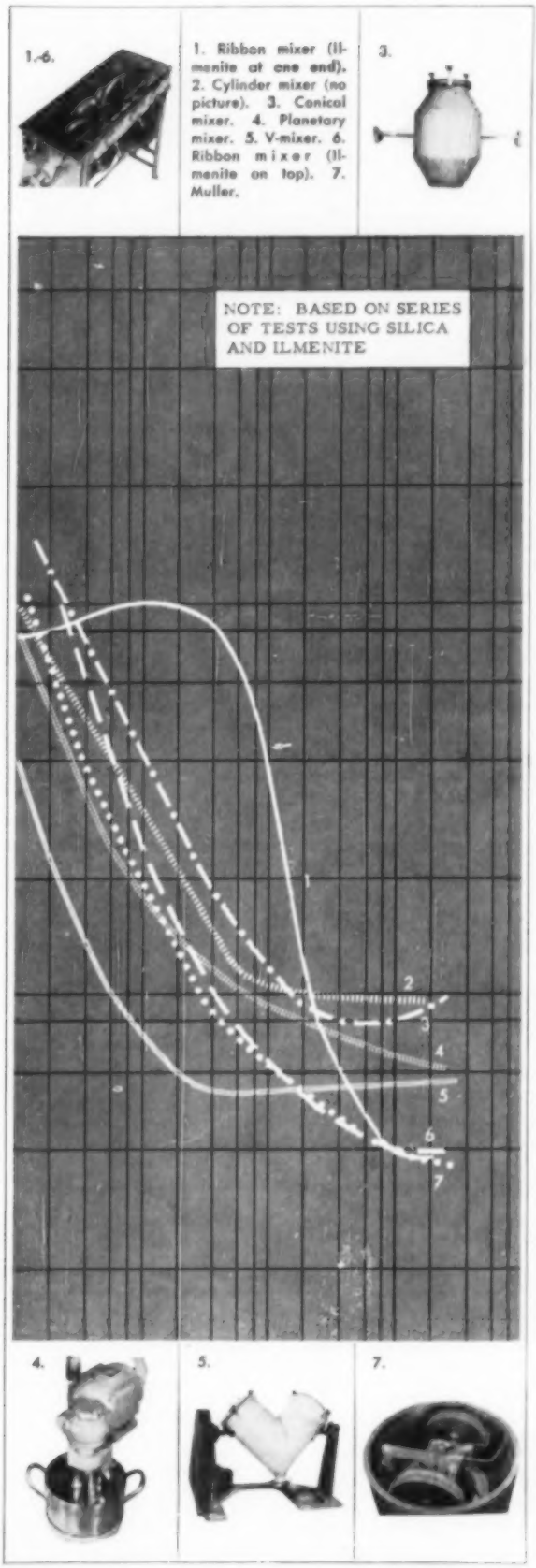

Which Mixer?

Large differences are found in rates of mixing produced by various types of mixing equipment and in the equilibrium uniformity of composition which can be obtained after long periods of operation. Selection of the best equipment for a specific mixing operation depends, however, not only on mixing performance but also on such factors as power consumption, ease of cleaning, time for filling and emptying, maintenance cost, and investment. This article describes the results of tests on the mixing performance of some of the common types of equipment.

performance of

DRY SOLIDS MIXING EQUIPMENT

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Many types of equipment are available for mixing dry-solid particles, but quantitative data comparing mixing performance are scarce.

In general, the performance of dry-solids mixing equipment is described in terms of the variance of composition of samples taken at various positions in the equipment and a plot is made of some function of the variance of composition against time of operation of the equipment.

Various techniques have been used for determining the composition of each sample. These methods include counting, chemical analysis, and solution of one component. It is usually necessary to remove samples from the batch of solid particles being mixed and then to analyze these samples.

J. B. Gray is associated with Engineering Research Lab, Engineering Department.

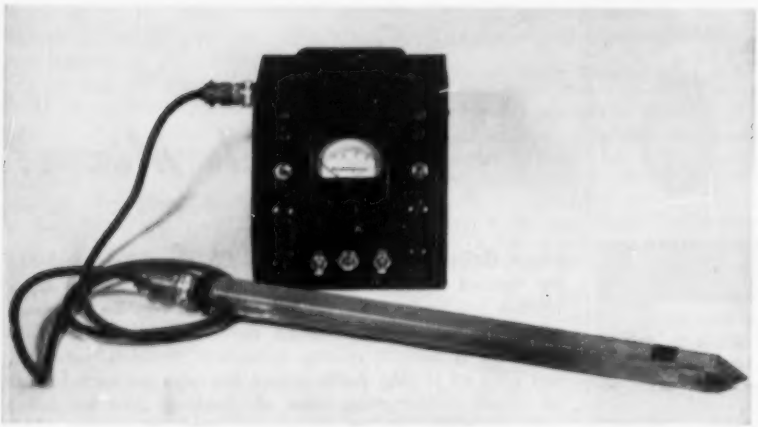

Fig. 1. Reflectivity probe.

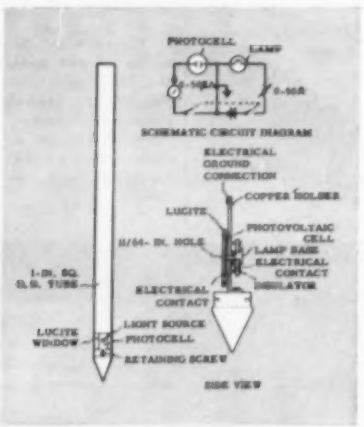

Fig. 2. Reflectivity probe: construction details.

Description of Equipment and Materials

To measure the composition of samples in the performance tests described in this paper, a sampling probe, having a light and photocell behind a glass window, was constructed. The probe measures the intensity of light reflected from a layer of particles immediately outside the glass window. For a mixture of light and dark particles and a light source of constant intensity, the readings of the photocell meter are uniquely related to the composition of the mixture. An over-all view of the probe and the meter for indicating the photocell output is shown in Figure 1. Details of construction and the electrical circuit used are presented in Figure 2.

Calibration curves relating the meter readings and the composition of solids for the three pairs of substances used in this study are presented in Figure 3. Carefully mixed 1-qt. samples were employed for these calibrations.

In the use of the photoelectric probe, care was taken to keep the window in a vertical position, since segregation of large and small particles occurred when the window was not vertical. Also, it was necessary to adjust the light intensity after every ten readings by inserting the probe in a 1-qt. sample of the lighter colored particles and to adjust the voltage to an arbitrary standard meter reading. Batteries were used to avoid voltage fluctuations. To obviate the need for frequent adjustment of light intensity

Table 2-a.—Operating Conditions of Tests

Test	Equipment type	Vol. cu.ft.	Rotational speed, rev./min.	Solids blended	Wt. of solids, lb.	Number of samples	Comments
6	Conical	0.45	32.6	Sand, Ilmenite A	16.5 1.65	10	
10	Conical	0.45	32.6	Sand, Ilmenite A	16.5 1.65	10	duplicate of test 6
12	Conical	0.45	84.5	Sand, Ilmenite A	16.5 1.65	10	
15	Conical	3.2	25.8	Sand, Ilmenite A	132 13.2	60	
16	Ribbon	3.2	90	Sand, Ilmenite A	159. 15.9	120	
17	Ribbon	3.2	90	Sand, Ilmenite A	98.5 9.8	36	
18	Ribbon	3.2	90	Sand, Ilmenite A	159 15.9	44	ilmenite placed at one end of mixer
19	Planetary	0.42	60	Sand, Ilmenite A	16.1 1.61	16	
20	Cylinder	0.67	48	Sand, Ilmenite A	36. 3.6	32	rotated on rollers
22	V	0.5	32.6	Sand, Ilmenite A	16.5 1.65	10	
23	V	0.5	32.6	Sand, Ilmenite A	16.5 1.65	10	
24	Muller	2.75	33.3	Sand, Ilmenite A	99 9.9	32	

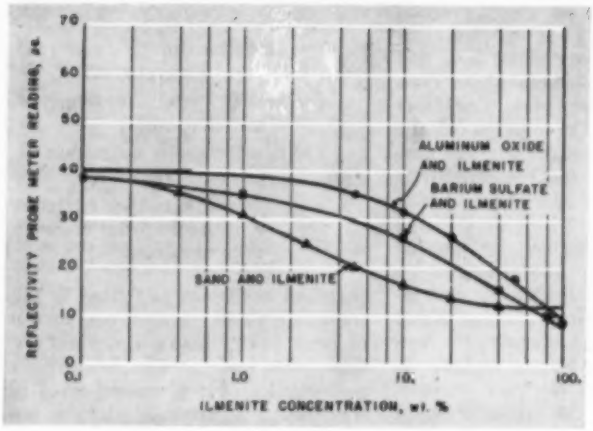

Fig. 3. Calibration curves for reflectivity probe.

in the first hour of use, the probe lamp was lighted for a period of 2 hr. before use. The probe window was wiped clean after each withdrawal of the probe from a bed of solids; accumulated fine particles which adhered to the window were removed in this manner.

Eight mixers were used in this investigation. In four of these mixers, a vessel was rotated and the solids were tumbled from wall to wall; in two of these mixers, the container was stationary and stirring devices moved and mixed the solids. In one mixer, a rolling and smearing action was used. In another, mixing occurred largely by the scattering induced when the particles struck a surface. These mixers are described as follows:

Tumbling Mixers

a. Double-cone or conical: The vessel consists of two cones joined by a short cylinder as shown in Figures 4 and 5.
b. V-mixer: The vessel consists of two cylinders formed in a right-angled V as shown in Figure 6.
c. Cylinder: A cylindrical vessel was rotated about its axis.
d. Baffled cylinder: The concrete mixer shown in Figure 7 was used.

Stirring Mixers

a. Ribbon: A spiral ribbon was rotated in a rectangular trough which had a semicylindrical bottom (see Figure 8).
b. Planetary: The mixer shown in Figure 9 was used. The vertical paddles rotate about an axis which is moved in a circular path at a lower rotational speed.

Smearing Mixer (Muller)

This mixer consists of two wheels which roll on a flat circular surface. The elevation of the wheels is adjustable so that the wheels do not rub on the flat surface and grind the particles. There is an additional mixing action provided by ploughs which move solids toward the wheels. The muller used in this work is shown in Figure 10.

Impact Mixer

A hammer mill was used as an impact mixing device under conditions for which particle breakdown was negligible (Figure 11).

Three pairs of solids were selected to provide data for comparing the mixing performance of the types of equipment just described. In each pair, one substance was light and the other dark so that the light reflectivity probe could be used for measuring the uniformity of mixing achieved.

In the first pair, the particles were of different size and density, and the

Fig. 4. Conical mixer, 3.2 cu.ft., 26 rev./min.

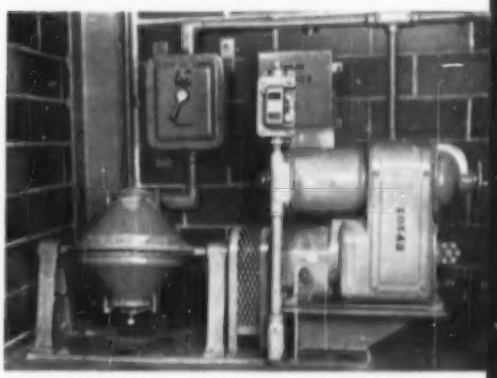

Fig. 5. Conical mixer, 0.45 cu.ft., 25-90 rev./min.

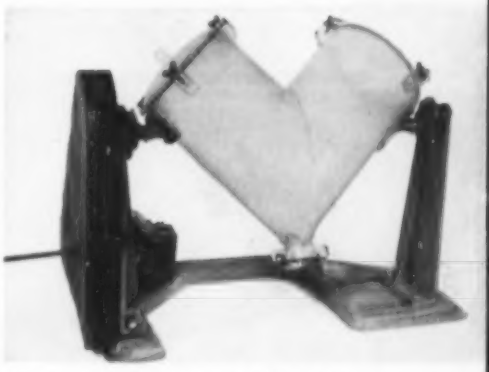

Fig. 6. V-type mixer, 0.5 cu.ft., 33 rev./min.

Fig. 7. Concrete mixer, 35-in. diam., 16 rev./min.

THE WORK OF OTHER RESEARCHERS

A number of investigators have applied statistical methods to the mixing of dry-solid particles. P. M. C. Lacey (3) discussed various concepts involved in analyzing either complete or partially mixed groups of solid particles. In addition, rates of mixing were discussed in detail. Weidenbaum and Bonilla (10) have analyzed theoretically the mixing which occurs in a rotating cylinder. Stange (7) discussed the effect of the number of samples on the precision of determination of mixing time. In a second paper (8) Stange uses statistical methods for evaluating by experiment how close a mixture of particles approaches the degree of uniformity of a completely random mixture.

Quantitative data have been published on the mixing performance of only a relatively few types of equipment for mixing dry solids. Data are available for a rotating horizontal cylinder (10) and an inclined rotating cylinder (1, 2, 9). The performance of a mixer of the muller type has been compared with that of a ribbon mixer by Lofton, Moore, Goldsmith, and Cooperman (4). Quantitative data on the performance of equipment for mixing moist solids such as clays, soils, and sand are presented by Smith (6) and by Michaels and Puzinauskas (5).

mixture was free flowing. In the second, the particles were nearly the same density and size, and the mixture was free flowing. In the third, the particles were the same density, and the mixture was not free flowing.

Properties of these solids are listed in Table 1.

For the mixture with particles of different size and density, a silica sand and a classified ilmenite (Ilmenite A) were selected. The silica particles were largely 65 to 200 mesh, and the ilmenite particles were predominantly finer than 200 mesh. The ilmenite particles were denser than the silica particles.

The free-flowing material with particles of the same size and density was a mixture of aluminum oxide abrasive grains and ilmenite ore. The aluminum oxide was 96% within 100 to 200 mesh in particle size, and the ilmenite ore was 83% in this size range. The ilmenite particles were rounded in shape but the aluminum oxide particles were irregular, sharp-edged fragments.

Precipitated barium sulfate and another ground and classified ilmenite (Ilmenite B) were selected as representative of a sticky or nonflowing type of mixture. The particles of these two materials were the same density.

Evaluating Mixing Performance

In a test of a piece of equipment, the component of the mixture which was used in larger proportion was dumped into the equipment first, and the darker component, which was present in smaller proportion, was placed on top. The rotation of the mixer was interrupted at intervals during its operation and the reflectivity probe was inserted to take readings at 10 to 100 positions which were spaced about equally throughout the mass of solids. The number of positions which can be selected is limited because inserting the probe in a mixture pushes aside particles and disturbs the material in closely adjacent regions. A larger number of readings increases the reliability of the results until the positions become so close that inserting the probe in one position distorts the particles at an adjacent position and gives a false reading. In the small equipment, such as the V-shaped mixer and the 0.45-cu. ft. conical blender, no more than ten readings could be taken for this reason.

The standard deviation of the reflectivity probe microammeter readings was computed for the readings taken after each interval of operation of a piece of equipment, and was used as a measure of the uniformity of composition achieved. The standard deviation of the probe meter readings was computed by the equation

$$s = \sqrt{\frac{\Sigma (i - \bar{i})^2}{n - 1}} \qquad (1)$$

where

n = number of probe meter readings, dimensionless.

i = probe meter reading, μa, microamperes.

$\bar{i}$ = average probe meter reading, μa, microamperes.

s = standard deviation of reflectivity probe meter readings, microamperes.

Standard deviations calculated in this way were plotted against the number of turns of the mixing equipment and these plots were used to compare the performance of the various types of equipment. In such a plot, a low standard deviation corresponds to a high uniformity of composition of the mixture.

An alternative method of expressing mixing performance employs a more direct measure of the variation in composition of samples after a fixed time of mixing. This variation can be expressed in terms of an upper and a lower ilmenite concentration between which 90% of the samples would be found if a large number of samples were taken. The length of mixing time was arbitrarily fixed at 10 min.; a shorter or longer time could have been selected.

The most direct method of determining this variation in ilmenite concentration would be to convert to ilmenite concentrations the microam-

Table 2-b.—Operating Conditions of Tests

Test	Equipment type	Vol. cu.ft.	Rotational speed, rev./min.	Solids blended	Wt. of solids, lb.	Number of samples	Comments
25	V	0.5	32.6	Al_2O_3 Ilmenite ore	14.5 3.6	10	
27	V	0.5	32.6	$BaSO_4$ Ilmenite B	6.4 1.61	10	
28	Conical	0.45	32.6	Sand, Ilmenite A	16.5 1.65	10	duplicate of test 6
29	Conical	0.45	32.6	Al_2O_3 Ilmenite ore	14.5 3.6	10	duplicate of test 25
30	Muller	2.75	33.3	$BaSO_4$ Ilmenite B	40.0 8.0	32	
31	Ribbon	3.2	90	$BaSO_4$ Ilmenite B	56.0 11.2	27	
32	Ribbon	3.2	90	$BaSO_4$ Ilmenite B	78.4 15.7	27	
33	Hammer Mill	....	9500	Mixture from test 32	27.2	30	
34-5	Conical	0.45	32.6	Al_2O_3 Ilmenite ore	14.5 3.6	10	replications of test 29
37-9	Concrete mixer	15	16.2	Sand, Ilmenite A	243 26.9	30	three tests at same conditions

Table 1.—Properties of Solids

Material	Sand	Ilmenite A *	Al_2O_3	Ilmenite ore	$BaSO_4$	Ilmenite B *
Particle density, g./cc.	2.6	4.3	4.0	4.3	4.3	4.3
Screen analysis						
48 to 65 mesh, wt. %	0.1	0.3	....	0.3	....	....
65 to 100 mesh	19.9	0.4	0.3	12.7	....	....
100 to 150 mesh	44.0	2.3	50.0	45.2	....	....
150 to 200 mesh	28.5	9.5	46.3	37.4	....	....
200 to 270 mesh	6.1	22.5	3.3	4.3	....	....
270 to 325 mesh	....	14.0	....	....	....	....
Through 325 mesh	....	51.0	....	....	....	....
Roller analysis						
80 to 40 μ, wt. %	....	55.6	....	....	....	6.7
40 to 20 μ	....	25.9	....	....	....	22.6
20 to 10 μ	....	5.7	....	....	....	25.4
Finer than 10 μ	....	6.7	....	....	....	43.6
Gravimetric sedimentation						
20 to 10 μ, wt. %	....	3.7	....	....	5.2	21.7
10 to 5 μ	....	1.8	....	....	....	16.5
5 to 2.5 μ	....	0.7	....	....	24.0	8.9
2.5 to 1.8 μ	....	0.7	....	....	20.3	3.4
Finer than 1.8 μ	....	2.7	....	....	48.5	12.7
Centrifugal sedimentation						
2 to 1 μ, wt. %	....	....	....	....	36.0	....
1 to 0.5 μ	....	....	....	....	1.6	....
Finer than 0.5 μ	....	....	....	....	11.4	....

* Ground and classified ilmenite ore.

meter readings obtained experimentally at the time in question, and to analyze the concentration data statistically. In most cases, suitable experimental data were not available for the different pieces of equipment at the same value of mixing time; a more indirect method of calculation was therefore employed. Values of the standard deviation of microammeter readings were obtained by interpolation of the data to obtain values of the standard deviation at 10 min. for each type of equipment. The range of ilmenite concentrations which would include 90% of samples if a large number of samples were taken was calculated as follows:

For systems with a normal distribution, plots on probability graph paper show how a sample attribute is distributed over the samples taken on the assumption that the number of samples is large. Plots were prepared as shown in Figure 12 to indicate how, for a given standard deviation of microammeter probe readings, the probe reading would be distributed over the samples.* Values of microammeter readings were read from these lines at the 5 and the 95% points for each value of standard deviation. By reference to Figure 3, ilmenite concentrations corresponding to the 5 and 95% points were then determined for each value of standard deviation. The resulting relation is shown in Figure 13 for sand and ilmenite.

The range of per cent ilmenite corresponding to any standard deviation can be read from such a plot. For a mixture of 9% sand and 91% ilmenite, and a standard deviation of 1 μa, 90% of the reflectivity-probe readings lie in the range of 6.9 to 12.7% ilmenite. Of these 5% are above and 5% are below these compositions. A standard deviation of 0.1 μa, which is roughly the limit to which the reflectivity-probe meter can be read, corresponds to a range of 8.9 to 9.4% ilmenite for the sand-ilmenite mixture used.

These relatively wide ranges in the sample composition are due in part to the small size of sample which is seen by the reflectivity meter. The layer of particles next to the probe window varies with particle size, but is probably less than 0.1 g. If a larger sample were used, a narrower range of compositions and a smaller standard deviation of probe meter readings would be obtained for the same time of mixing. However, the relative performance of the various mixers would remain the same if the sample size were increased for all the mixers. For a 100-fold increase in sample size, the standard deviations would be lowered by a factor of 10. A standard deviation of 1 μa would then become 0.1 μa.

The operating conditions used in the evaluation of the performance of various types of equipment are summarized in Table 2. This table also includes data on the number of samples.

Results of Experimental Mixing Evaluations

Results of the various performance tests are divided into three groups, according to the type of solids. In the first group, eight mixers are compared when mixing sand and ilmenite

* A straight line is obtained in such a plot for a normal distribution of data, and the slope of the line is related to the standard deviation of the data. The standard deviation of data on such a straight line is equal to the difference of the ordinates for the 84.1 and 50% abscissas.

Fig. 9. Planetary mixer, 0.4 cu.ft., 60 rev./min.

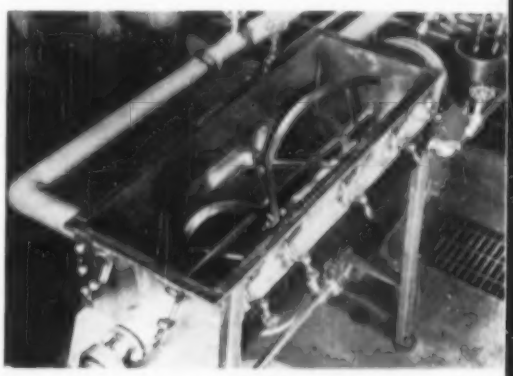

Fig. 8. Ribbon mixer, 3.2 cu.ft., 90 rev./min.

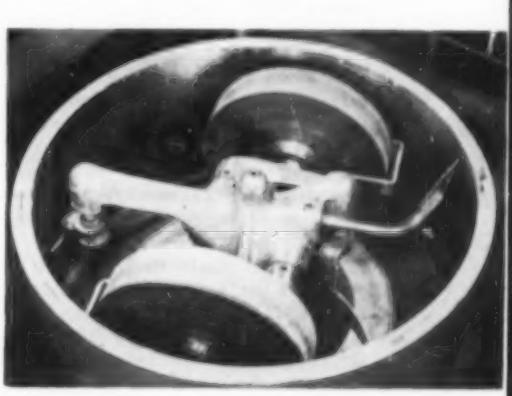

Fig. 10. Muller, 2.8 cu.ft., 33 rev./min.

Fig. 11. Hammer mill, 8-in. diam., 9,500 rev./min., ½-in. diam. holes in screen.

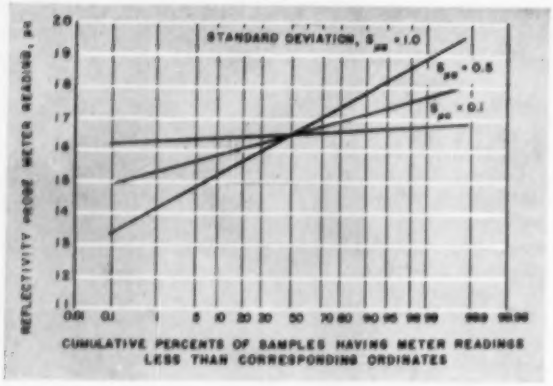
STANDARD DEVIATION, S_{pa} = 1.0
S_{pa} = 0.5
S_{pa} = 0.1
REFLECTIVITY PROBE METER READING, pa
CUMULATIVE PERCENTS OF SAMPLES HAVING METER READINGS LESS THAN CORRESPONDING ORDINATES

Fig. 12. Standard deviation of reflectivity-probe meter readings.

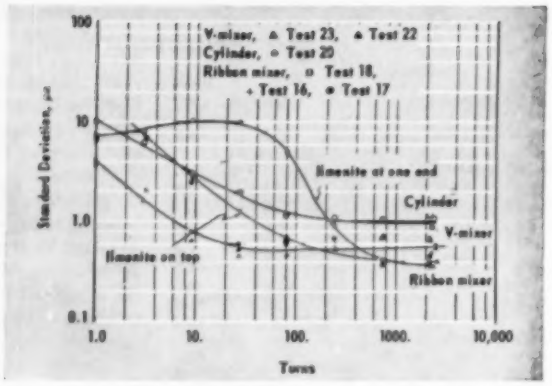

Fig. 14. Mixing of silica and ilmenite in V-mixer, cylinder, and ribbon mixer.

A. This mixture consists of free-flowing particles which segregate readily because of differences in particle size and density. In the second group, two mixers are compared when mixing aluminum oxide and an ilmenite ore—a free-flowing mixture of particles which are nearly the same size and density. In the third group, three types of equipment for mixing barium sulfate and Ilmenite B are compared. This is a mixture of fine particles which agglomerate readily and are not free flowing.

1. MIXING OF SOLIDS OF DIFFERENT PARTICLE SIZE AND DENSITY

In Figures 14 to 17, performance data are presented for eight pieces of equipment when mixing material containing 91% sand and 9% Ilmenite A.

In such plots, an initially rapid decrease in standard deviation is followed by a much slower decrease. In some cases, an equilibrium standard deviation is reached, corresponding to an equilibrium distribution of particles in the equipment. In other cases, extended periods of operation showed unmixing or segregation to be taking place.

From Figures 14 to 17, it can be seen that the V-type mixed the most rapidly. The ribbon mixer and the muller mixed more slowly, but achieved a more uniform mixture after an extended period. In respect to the uniformity ultimately achieved, the poorest performance was shown by the conical mixer and the rotating cylinder. The planetary-paddle type of mixer achieved a uniformity intermediate between that achieved by the conical and ribbon mixers. Two sizes and designs of conical mixers were used. The smaller of the two mixed more rapidly initially and reached a maximum uniformity of composition sooner than the larger one. These results, however, are not suitable for deriving scale-up relations because the two sizes were not geometrically similar.

In the case of the ribbon mixer, the rate of mixing in a direction along the axis of rotation was not as high as in a direction perpendicular to the axis of rotation. This is illustrated in Figure 14. It was found that the initial rate of mixing was slower when the ilmenite was placed at one end of the mixer than when it was spread along the upper surface of the sand.

All rotational types of equipment appear to have a slower mixing action along the axis of rotation than for directions perpendicular to this axis of rotation. Equipment which is short in an axial direction relative to the other dimensions should suffer less from this defect than equipment which is long in an axial direction.

A concrete mixer was found to have a tendency to unmix when mixing was continued beyond sixty-four turns (4-min. operation). This decrease in uniformity of mixing can be seen in Figure 17. Apparently the mixing and segregation processes occurring in the mass of particles reach an intermediate state of greater uniformity than that which exists later when the rates of mixing and segregation become balanced. In this experiment, the mixing was not continued until equilibrium was reached.

The ranges of per cent ilmenite achieved after a 10-min. operation are presented in Table 4. These ranges were obtained as just described with the use of the relationship presented in Figure 13. The more narrow the range of per cent ilmenite, the better is the mixing performance. The mixer at the top of Table 4 performed most effectively, the mixer at the bottom least effectively.

2. SOLIDS OF THE SAME PARTICLE SIZE AND DENSITY

Two types of equipment were used for mixing aluminum oxide and ilmenite ore, which are free-flowing materials of nearly the same particle size and density. The V-mixer and conical (double-cone) mixer were selected because they were representative of a fast and a slow method, respectively, of mixing sand and Ilmenite A. The difference between the V-mixer and the conical mixer proved not to be as large when mixing aluminum-oxide and ilmenite ore as when mixing sand and Ilmenite A. This is shown in Figure 18.

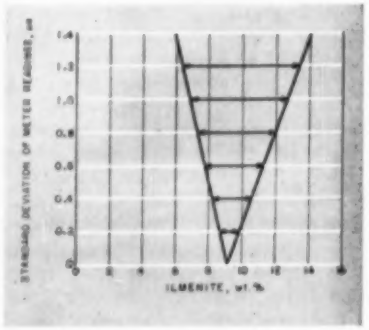

Fig. 13. Relationship between standard deviation and range of per cent ilmenite for 90% of sample probe meter readings in sand-ilmenite mixtures.

It is surprising that ilmenite ore and aluminum oxide should show a tendency to unmix in the conical mixer. Apparently the differences in particle shape and density are enough to cause segregation as the conical mixer rotates. The aluminum oxide particles are sharp-edged fragments, and the ilmenite ore has rounded particles. There is also a 5% difference in particle density.

3. MIXING OF NONFREE-FLOWING FINE PARTICLES

A ribbon mixer, V-mixer, muller, and hammer mill were used for mixing barium sulfate and Ilmenite B. These substances were not free flowing, and there was a strong tendency

for agglomerates of ilmenite and of barium sulfate to form in the operation of the V-mixer and the ribbon mixer. These agglomerates became smaller as mixing was continued. According to the reflectivity-probe data in Figure 19, the ribbon mixer appeared to achieve a greater uniformity of mixing than the muller. However, the agglomerates in the ribbon mixer after 2,000 turns were smaller than the probe window and apparently had little effect on the standard deviation of the probe readings. There were no agglomerates observed after 2,000 rev. in the muller.

In another method of mixing non-free-flowing fine particles (test 33), a ribbon mixer was used to premix the barium sulfate and ilmenite for 1 min. A standard deviation of 0.14 was obtained in this operation. This premixing was followed by a single, rapid pass through a hammer mill to break up agglomerates. A standard deviation of 0.11 was then obtained. The combination of these two mixing actions produced a mixture of barium sulfate and ilmenite which not only

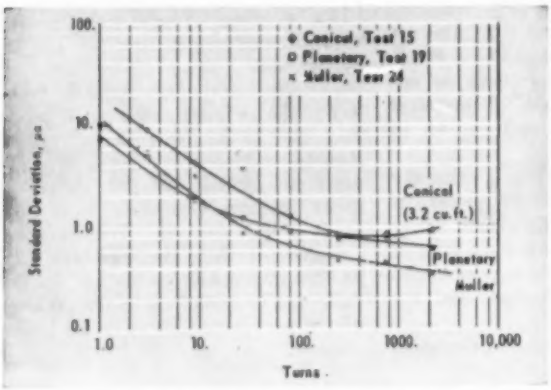

Fig. 15. Mixing of silica and ilmenite in muller, planetary, and conical mixers.

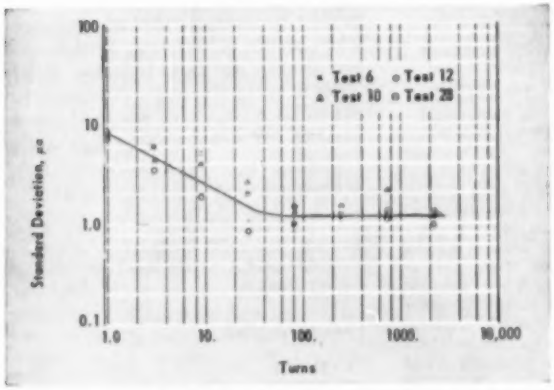

Fig. 16. Mixing of silica and ilmenite in a conical mixer (0.3 cu.ft.).

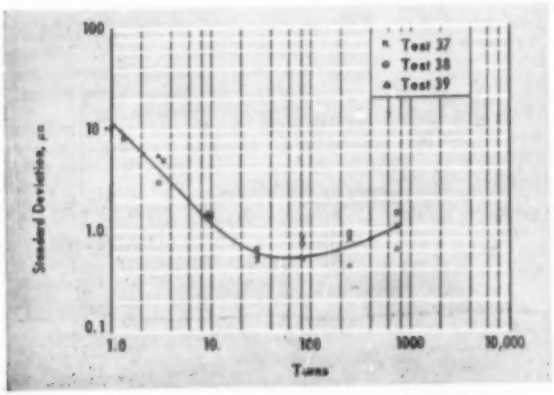

Fig. 17. Mixing of silica and ilmenite in a concrete mixer.

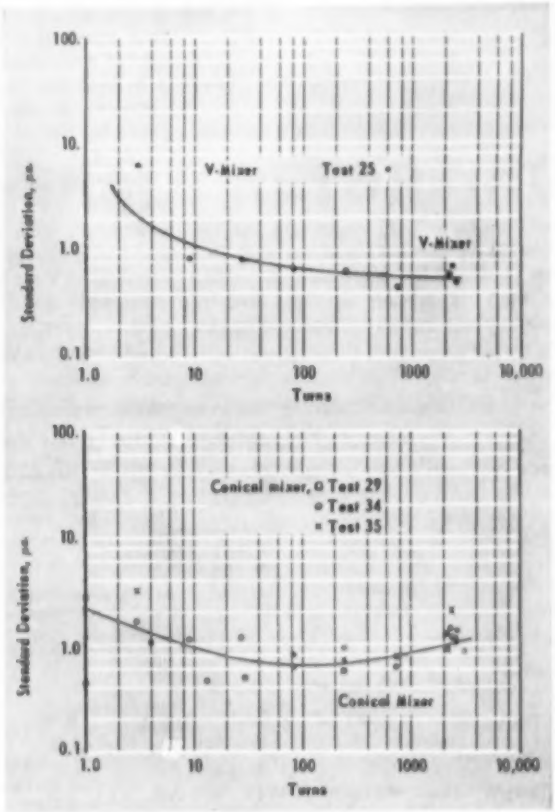

Fig. 18. Mixing of aluminum oxide and ilmenite in conical (0.45 cu.ft.) and V-mixers.

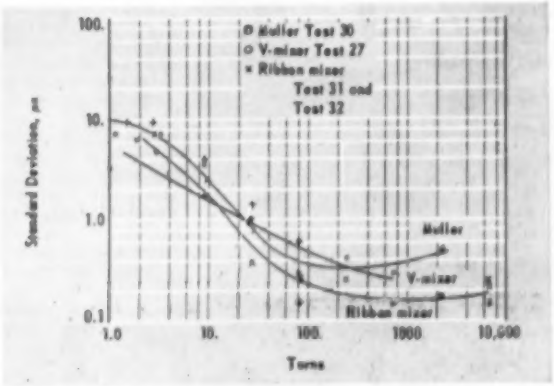

Fig. 19. Mixing of barium sulfate and ilmenite in muller, ribbon, and V-mixer.

Table 4.—Performance of Dry-Solids Mixing Equipment: Particles of Different Size and Density (Sand-Ilmenite)

Type of mixer	Performance, range of per cent ilmenite *
Ribbon mixer	2.3
Muller	2.8
V-mixer	3.2
Concrete mixer	3.6
Planetary paddle	4.2
Double-cone, 3.2 cu.ft.	5.0
Cylinder	5.8
Double-cone, 0.45 cu.ft.	7.1

* For 90% of meter readings after 10-min. operation of mixer.

was uniform with respect to the reflectivity-probe readings but also had no observable agglomerates. This method of mixing is rapid and is adaptable to both batch and continuous mixing.

REPRODUCIBILITY OF RESULTS

In Table 3 are presented 90% confidence limits for some of the performance results. These data provide a measure of the variability or reproducibility of the equilibrium standard deviations obtained after a long period of mixing in a single test; they also provide a measure of the reproducibility of replicate tests. These 90% confidence limits represent the range of values of standard deviation within which one is 90% sure the true standard deviation lies. The effect of such uncertainties in the standard deviation is to introduce an uncertainty in the ranges of per cent ilmenite shown for each mixer in Table 4.

In general, the confidence limits are narrower for the larger pieces of equipment, such as the ribbon mixer and the muller, in which more samples were taken than for the smaller equipment such as the V-mixer and the conical mixer.

In one case, the standard deviation of probe readings at the end of the mixing cycle approached the limit of precision in reading the reflectivity meter scale. This limit is ± 0.1 μa. For example, in the case where barium sulfate and ilmenite were mixed in a ribbon mixer (Test 31) the standard deviation of the probe readings was 0.2 at 2,000 turns. This might be expected, because the mixture was one in which the insertion of the probe would not tend to cause segregation of the light and dark particles.

For mixtures of sand and ilmenite as well as of aluminum oxide and ilmenite, some portion of the values of the standard deviations found in Table 3, perhaps as large as 0.2 μa, is probably due to sampling errors rather than to real nonuniformities in composition. In one case, a series of meter readings was taken with only sand in the V-mixer. The standard deviation of these readings was 0.25 μa. Such sampling errors are apparently due to variations in the packing of the particles adjacent to the probe window.

Table 3.—Reproducibility of Mixing Test Results *

	Among readings within tests			Between average readings of duplicate tests		
		90% confidence limits for true std. deviation			90% confidence limits for true std. deviation	
	standard deviation	lower	upper	standard deviation	lower	upper
SILICA & ILMENITE						
V-mixer						
test 22	0.49	0.42	0.59	0.24	0.18	0.38
test 23	0.69	0.56	0.84			
Ribbon mixer						
test 16	0.38	0.34	0.43			
Muller						
test 24	0.35	0.30	0.42			
Conical, 0.45 cu.ft.						
test 6	1.17	0.85	1.92	0.15	0.09	0.35
test 10	1.34	0.98	2.20			
test 28	1.15	0.95	1.49			
Al_2O_3 & ILMENITE						
V-mixer						
test 25	0.60	0.49	0.77			
Conical, 0.45 cu.ft.						
test 29	1.06	0.86	1.29	0.45	0.33	0.74
test 34	1.17	0.96	1.52			
test 35	1.56	1.28	2.02			
$BaSO_4$ & Ilmenite						
Ribbon mixer						
test 31	0.20	0.17	0.23			

* After 2,000 or more turns of mixer.

Note: All numbers are microamperes.

Conclusions

The results just described show appreciable differences in the rates of mixing by various types of equipment when solids of different particle size and density are mixed. These differences in performance are reduced when the solids mixed have nearly the same particle size and density.

Acknowledgment

F. E. Bechtel, formerly of the Engineering Research Laboratory, developed the reflectivity probe used in this investigation.

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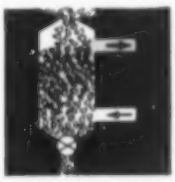
Presented at A.I.Ch.E. meeting, Pittsburgh, Pennsylvania.

Promotion of nucleation of oil vapor in a gas stream rising through a bed of irregularly shaped solids by seeding with sodium chloride or aluminum oxide has been found to simplify the later recovery of the oil by condensation. Translated, this technique may find other important uses in chemical processing.

the role of NUCLEATION *in* OIL-SHALE RETORTING



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Oil shale is a sedimentary rock that contains a solid organic substance of indefinite composition known as kerogen. On heating oil shale, the kerogen undergoes thermal decomposition, and the vapor products of the decomposition can be condensed as shale oil. The process of heating the oil shale is known as retorting. The crude shale oil can be refined to produce fuels similar to those derived from petroleum.

A vast deposit of oil shale exists in Colorado, Utah, and Wyoming, and in northwestern Colorado alone is an area of approximately 1,000 sq. miles underlain by oil shale 500 ft. thick and assaying 15 gal. oil/ton. One portion of this measure, known as the "Mahogany ledge," ranges up to 100 ft. in thickness and averages 30 gal./ton. A conservative estimate of the recoverable shale oil in this portion of the deposit exceeds 100 billion barrels (*1*). Because of their magnitude these deposits comprise an important natural resource for the production of synthetic liquid fuels.

In the past the production of liquid fuels from oil shale has been considered only when there was serious doubt of the adequacy of petroleum reserves. Today as a result of technology developed by both Government and industry, it appears that it will soon be possible to produce oil-shale fuels at costs that will make them a feasible supplement to petroleum.

The plan which looks the most promising now for the production of liquid fuels from oil shale can be divided into three phases: (1) mining and crushing the raw shale, (2) retorting to produce a crude shale oil, and (3) refining the shale oil into finished products. It is evident that large tonnages of oil shale must be mined at low cost to make extraction of shale oil economically practicable. The nature of the deposits is conducive to such an operation. Refining of liquid shale oil presents problems not encountered in petroleum processing, but several promising methods are available (*4*).

In commercial production of shale oil tremendous quantities of shale must be processed and, since the inorganic portion must also be heated to the order of 900° F., the quantity of heat that must be exchanged in the retorting step is consequently large. Therefore, for a retorting process to be economically attractive, the heat-transfer and materials-handling problems must be solved by such simple procedures that the capital and operating costs are low. Also, the area in which our oil-shale reserves occur is semiarid, and use of process water would be undesirable. By applying nucleation techniques it has been possible to devise a process that satisfies these requirements to a high degree.

Gas-Combustion Process Description

Figure 1 is a schematic flow diagram of the 6-ton-a-day gas-combustion pilot plant operated at Rifle, Colorado.

Raw shale enters at the top of the retort and moves downward by gravity as a moving bed. As the shale descends it passes progressively through a product-cooling zone, a retorting zone, a combustion zone, and a heat-recovery zone.

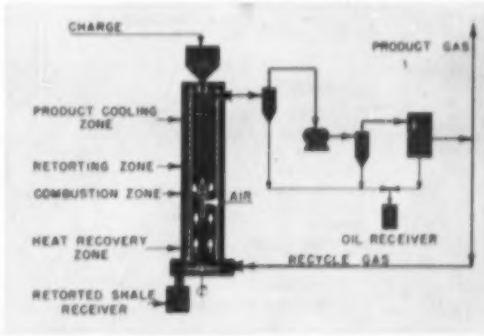
A portion of the cold product gas stream is used to cool the retorted shale in this lower section. This recycle gas contains some combustibles which, after being preheated by contact with the hot retorted shale, will burn quite readily when mixed with the air introduced beneath the cone shown in the figure. A portion of the carbonaceous residue remaining on the retorted shale also is consumed. The resultant hot flue gas passes upward through the shale bed and heats the shale to retorting temperature. Kerogen is converted to shale-oil vapors and gases, which are swept upward and away from the retorting zone by the hot flue gas. The gas and vapor stream are cooled by the incoming shale in the product-cooling zone at the top of the vessel, and the oil vapors are condensed as an oil mist in the gas stream. The product stream from the retort first passes through a woven-wire packing-type separator, which removes the larger mist droplets from the gas stream. The remaining oil-mist droplets are agglomerated in passing through the gas blower, and almost complete recovery of the oil can then be effected by two centrifugal separators in series. However, an electrostatic precipitator is used also for final cleanup of the gas system.

By cooling and condensing the oil vapors as a mist in the product-cooling zone and removing the oil in this form, the requirements of a feasible retorting process are achieved to a high degree. The product stream is cooled to 130° F. by contact with the cool incoming shale, and no further cooling is necessary. Thus, the use of cooling water and costly heat exchangers is avoided. Yet this is accomplished with no sacrifice in simplicity of process. In this entire heat transfer and product recovery operation, nucleation of hot gas to noncoalescing liquid droplets is the key to success.

Requirements for Mist Formation

Before the gas-combustion process was developed, the concept of recovering oil from a shale retort in a form of a mist was generally unknown. Operation of a gravity shale-flow retort with a product-gas temperature below the dew point of the oil was considered undesirable because shale oil is thermally unstable, and it was believed that successive condensation

Fig. 1. Flow diagram of gas combustion pilot plant.



* Mr. Putman is now with Dow Chemical at Midland, Michigan.

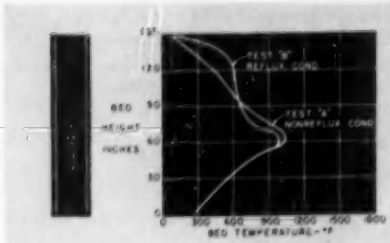


Fig. 2. Bed temperature profiles—tests A & B.

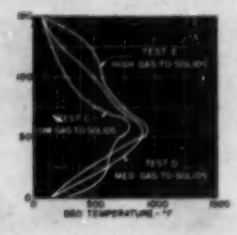


Fig. 3. Typical bed temperature profiles.

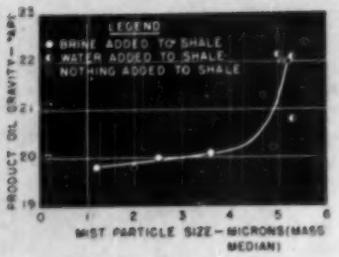

LEGEND
BRINE ADDED TO SHALE
WATER ADDED TO SHALE
NOTHING ADDED TO SHALE
PRODUCT OIL GRAVITY - °API
MIST PARTICLE SIZE - MICRONS (MASS MEDIAN)

Fig. 4. Effect of mist particle size on oil properties.

on the surface of the shale and redistillation of the oil would result in a poor yield of highly cracked oil. For this reason, the original pilot plant incorporated a provision for cooling the product stream. After a few tests on this plant, the possibility of preferentially condensing the oil vapors as micron-size mist droplets in the gas stream and removing the oil in this form was discovered.

However, subsequent operations disclosed that on some occasions the process failed to function properly. Under the same operating conditions, two drastically different results could be achieved. Data tabulated in Table 1 are representative examples. In the example cited, the operating conditions over which a reasonable degree of control could be exercised are almost identical, yet in one a low yield of lighter oil was produced. To differentiate between the two types of operation, the tests in which the lighter oil was produced were termed refluxing tests and the other type nonrefluxing. It was deduced that when the lighter oil was produced either the vapors did not condense preferentially in the gas stream or the mist particles were so large that they separated from the gas stream by impingement on the shale particles.

As the first step in solving this dilemma, it was necessary to understand how the shale-oil mist was formed in the process. Considerable fundamental work has been done in recent years on the mechanism of mist formation, and the basic requirements are well established. To form an oil mist within a body of gas containing oil as vapor, two conditions must be satisfied. They are:

1. **The mixture of oil vapor and gas must be so cooled that the gas becomes supersaturated with respect to the oil vapor.**
2. **Nucleation must occur, that is, condensation of the oil as drops must be initiated.**

In a consideration of the first condition, it is understood that when an inert gas-vapor mixture is passed over a surface that is sufficiently colder than the mixture, heat and mass flow to the surface simultaneously. Therefore, in a countercurrent heat exchanger, such as the product-cooling zone in the gas-combustion process, to satisfy the first requirement, the superheated vapor-gas mixture must be cooled in such a manner that the relative rate of cooling is much greater than the rate of mass transfer. Fortunately, the rate of mass transfer is proportional to the diffusivity of the vapors; and, since high molecular materials such as shale oil have a characteristically low diffusivity, it is relatively easy to produce a high degree of supersaturation when a gas stream containing these vapors is cooled; and it was concluded that the results cited in Table 1 for test B were not due to failure to satisfy this requirement.

With respect to the requirement that nucleation must occur, the early investigators learned that with most materials a very high degree of supersaturation is required t initiate nucleation unless some contaminants, which they termed nuclei, are present. The first type of condensation is termed homogeneous nucleation or self-nucleation and the latter heterogeneous nucleation. In the case of heterogeneous nucleation, the number of particles formed is related to the number of nuclei originally present. However, one group (*5*) of investigators reports that with materials of low vapor pressure, rapid cooling produces so high a degree of supersaturation that self-nucleation predominates even in the presence of foreign nuclei and small particles are formed. Slower cooling, on the other hand, results in growth on foreign nuclei.

With shale oil, nuclei might consist of naturally occurring particles of shale dust or carbon. If a sufficiently rapid rate of cooling could be achieved in the zone of initial condensation, aggregates of oil molecules might act to provide self-nucleation.

Table 1.—Comparison of Refluxing and Nonrefluxing Tests

Test no.		A	B
Operating conditions:			
Shale grade	gal./ton	21.1	20.8
Shale size	in.	+½—1	+½—1
Raw shale rate	lb./hr.	620	620
Air rate	std.cu.ft./ton	4,200	4,000
Recycle gas rate	do.	17,000	16,800
Results:			
Oil yield	vol. % Fischer assay	93	72
Oil gravity	° API	19.7	22.8
Viscosity	S.S.U. at 130° F.	130	60
Retorted shale assay	gal./ton	0.5	1.8

Self-Nucleation Phenomenon

Examination of the bed-temperature profiles for a number of tests was quite revealing. These bed-temperature profiles were prepared by plotting as a function of bed height the temperatures indicated by thermocouples inserted a short distance into the bed. Such profiles are shown in Figure 2 for tests A and B cited previously in Table 1. These tests are a typical example, from which it was observed that the rate of change of bed temperature with bed height was much lower in the 600° F. range, for the refluxing tests. This temperature corresponds with the calculated dew point of the vapor gas mixture. The difference in the cooling curves was interpreted as an indication that the cooling rate in the zone of initial condensation might be influ-

encing the nucleation phenomenon. For, with a rapid cooling rate, self-nucleation predominated, and a large number of fine particles were formed; whereas with a low cooling rate a small number of large particles were formed on foreign nuclei; and these particles were large enough to be separated from the gas stream by impingement on shale particles causing a refluxing condition.

This example and similar ones alone cannot be accepted as positive evidence for the above explanation. In this instance, the shape of the curve for the example cited in Figure 2 is both a result and cause for refluxing. A refluxing condition tends to depress the cooling rate in the critical zone because any oil deposited on the shale will revaporize at a temperature only slightly higher than the dew point and recondense at a temperature only slightly less. This causes the temperature of the shale to approach that of the vapor-gas mixture in this zone where a high temperature differential is required to achieve a high cooling rate. Thus, once a refluxing condition is established, it will persist. It has been found that if a favorable cooling rate is once established, such as for test A, the process also will maintain this condition.

Other factors affect the shape of the cooling curve, the ratio of gas to solids in the product cooling zone being perhaps the most important. This section is merely a gas-to-solids heat exchanger. Considerable fundamental study (*2*) has been devoted to the characteristics of gas-to-solids heat exchangers. These studies indicate that the ratio of gas-to-solids in such an exchanger has a pronounced effect on the temperature history from top to bottom.

As applied to the gas-combustion process, a low gas-to-solids ratio in the product cooling zone should and does tend to give a cooling path as indicated for test C in Figure 3. A high gas-to-solids ratio tends to give a cooling path as indicated for test E. In the gas-combustion process refluxing never occurs at low gas-to-solids ratios and may or may not occur at the intermediate gas-to-solids ratios, the determining factor in this case being whether the preceding test was a refluxing or nonrefluxing test. In this case test D would be nonrefluxing.

The cooling rate also can be increased by either lowering the bed height or increasing the gas and shale rates proportionally. However, lowering the bed height decreases the heat- and oil-recovery efficiencies, and at high gas rates a point is reached where the increase in the cooling rate is nullified by the greater rate of impingement on the shale. There are also certain inherent disadvantages in the use of a low gas-to-solids ratio to control the nucleation phenomenon. All these considerations point up the desirability of a method of controlling the nucleation phenomenon that is independent of the other process variables.

Sodium Chloride Nucleation

It was observed in the literature that sodium chloride crystals were used frequently as condensation nuclei for materials similar to shale oil. One specific method was to vaporize sodium chloride in a gas stream, followed by rapid cooling which caused sodium chloride crystals to precipitate throughout the gas stream. It appeared that by the addition of a solution of sodium chloride to the shale it should be possible to do likewise in the gas-combustion process. It was reasoned that the water would evaporate, leaving a thin film of sodium chloride on the shale. When this shale with the film of sodium chloride passed through the combustion zone, a portion of the sodium chloride would sublime. When the gas stream was cooled in the upper zone, sodium chloride crystals would precipitate throughout the gas stream.

A rather extensive evaluation of the effect of brine addition revealed the following facts.

1. **The degree of refluxing was related to mist particle size.**
2. **Mist particle size could be controlled by adding sodium chloride solution to the shale.**
3. **Sodium chloride and not water was the effective agent.**

To establish the above relationship, three groups of four consecutive tests were performed. For the first test in each group the retort was first brought to steady-state condition in such a manner that refluxing would occur, and nothing was added to the shale during the test that followed. For the next step in the group water was added to determine whether water alone would eliminate refluxing. In the third test saturated brine was added to determine its effect. Previous work had indicated that the preceding steady-state condition was the deciding factor as to whether or not the retort would reflux at some conditions. Therefore, a fourth test was scheduled without an additive to see whether or not the retort would return to a refluxing condition on the assumption that refluxing was eliminated during the second or third test.

A different gas-to-solids ratio was used for each group, previous experience having indicated the quantity of gas in the product cooling zone to be one of the more important variables with respect to the refluxing tendency of the process.

Refluxing produces a lighter, less viscous oil product; therefore, the properties of the oil were accepted as a measure of refluxing.

It was also necessary to obtain a value for the size of the mist particles. To do so, the oil recovered by the first separator was measured, and the aver-

Fig. 5. Chronological history for additive test.

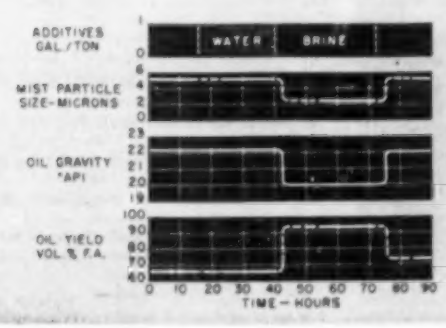
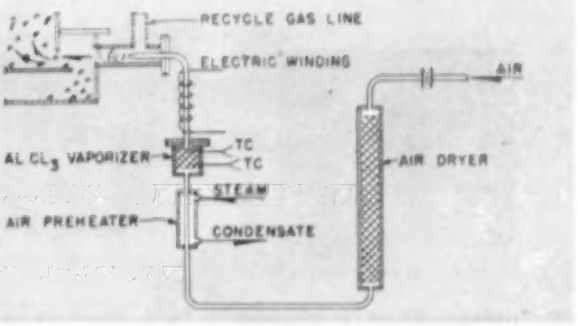


Fig. 6. Schematic flow diagram of $AlCl_3$ nuclei generator.



age size of the mist particles was determined from an efficiency curve for this unit.

The relationship between mist particle size and degree of refluxing is shown in Figure 4. Product oil gravity for the composite sample for each test has been plotted as a function of the mass median particle size. The correlation indicates that for the particular size range, shale, and bed height used in these tests the average particle size must be less than 4 μ to minimize refluxing.

The effect of additives on mist particle size is also shown in Figure 4. Tests in which additives were used are distinguished by different symbols. In every one, the size of the mist particles was less than 4 μ when brine was added to the shale and 5 μ or larger when water was added. This indicates that mist particle size can be controlled by adding brine to the raw shale and that sodium chloride and not water is the effective agent.

It is interesting to note that the mist particles were only 2 μ for the fourth test in the group at the lowest gas-to-solids ratio used. This is indicative of the effectiveness of the self-nucleation mechanism at rapid cooling rates.

In every test the type and amount of oil collected were similar when brine was added to the shale. This indicates that, when mist particle size is controlled independently, the type and amount of oil produced are not influenced by the gas-to-solids ratio over the range studied.

The chronological changes in the product-oil gravity and mist particle size, as well as whether additives were used, are shown in Figure 5 for one group of four tests. Here a pronounced change occurred 2 hr. after the brine was added. This period corresponds with the time required for the first shale particles wet with brine to reach the combustion zone. Three hours after the last brine was added, the retort had reverted to the original condition.

This study established that the degree of refluxing in the gas-combustion process is controlled primarily by mist particle size and that mist particle size can be controlled by sodium chloride nuclei. However, sodium chloride has a low vapor pressure, and subsequent investigations indicated that the maximum bed temperatures, and not the amount of sodium chloride added, controlled the degree of nucleation. Investigation of several other salts did not disclose any superior to sodium chloride. Although the brine-addition method has merit because of its simplicity, it is undesirable to have the mist-formation phenomenon dependent upon any retorting conditions. A method of generating nuclei outside the retort and introducing them into the retort with the recycle gas would be more satisfactory.

Aluminum Oxide Nucleation

One such method has been studied. Aluminum chloride vapors were introduced into the recycle gas stream where the aluminum chloride reacted with a portion of the water vapor present to form aluminum oxide nuclei. Figure 6 shows the essential features of the equipment.

A metered quantity of compressed air was passed through a Drierite column to remove any water vapor and then preheated to the desired temperature level in a steam-jacketed heat exchanger before it passed through the aluminum-chloride vaporizer. The vaporized aluminum chloride and warm air then passed through a jacketed line into the recycle-gas line, where it contacted the water vapor in the recycle-gas stream and reacted to form hydrated aluminum oxide particles. These particles were then carried up through the retort by the gas stream and dehydrated by the time they reached the product-cooling zone, where they acted as nuclei for the oil vapors to condense upon.

Three extended retorting tests have been made with this method of nucleation. Since the quantity and temperature of the air should affect the quantity of aluminum chloride vaporized, two air rates and two temperatures were selected for these tests. The size of the mist droplets produced within the retort was measured with a jet impactor (*3*) to determine the effectiveness of the aluminum oxide nuclei.

Examination of the data indicated that the amount of aluminum chloride added to the recycle gas stream determined the size of the mist droplets. This is shown in Figure 7, in which the mass median particle size of the mist droplets has been plotted vs. the amount of aluminum chloride added.

The particle-size distribution for several representative mists is shown in Figure 8. The first line represents the distribution for a refluxing test in which no nuclei were added; the second is the distribution for a test with aluminum oxide as nuclei; the third is a test in which sodium chloride was the nuclei. It will be noted that the mist droplets are more nearly uniform in size with the aluminum oxide nuclei, as indicated by the slope of the line. This type of distribution is quite desirable because few particles are produced which are difficult to separate by inertial separators but yet the largest are small enough to pass through the shale bed with a minimum amount of impingement.

Future Program

The chief disadvantage of aluminum oxide nuclei is the cost of the aluminum chloride. In the near future a generator will be tested in which sodium chloride will be vaporized in an oxyacetylene torch mounted in the recycle-gas stream. It is hoped that the localized temperatures in the flame will be hot enough to vaporize an adequate amount of sodium chloride without raising the temperature of the recycle-gas stream appreciably and that, when the gases become mixed, suitable size sodium chloride crystals will precipitate throughout the gas stream.

Acknowledgment

The author is indebted to Boyd Guthrie, superintendent of the Oil-Shale Experiment Station at Rifle for his advice and guidance in the preparation of the manuscript, and also to Simon Klosky of the Washington staff of Bureau of Mines for his thorough review.

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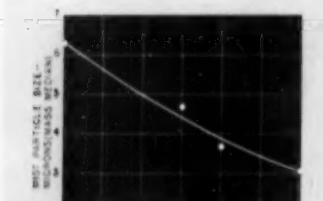

Fig. 7. Effect of $AlCl_3$ on mist particle size.

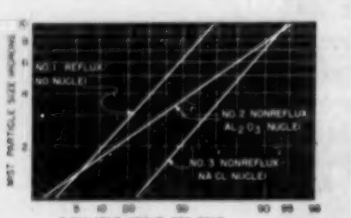
NO 1 REFLUX NO NUCLEI
NO 2 NONREFLUX Al2O3 NUCLEI
NO 3 NONREFLUX NaCl NUCLEI
MIST PARTICLE SIZE-MICRONS
CUMULATIVE WEIGHT PER CENT

Fig. 8. Typical mist particle size distributions.

Presented at A.I.Ch.E. meeting, Houston, Texas.

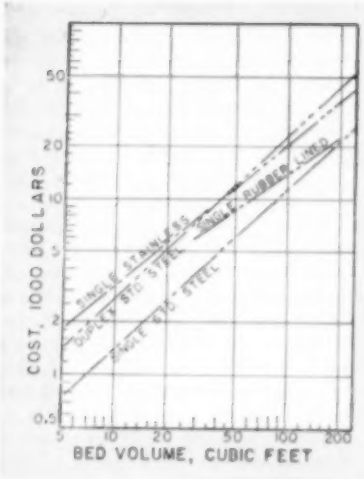

Fig. 7. Estimated costs (f.o.b.) for anion exchange units, strongly basic resin.

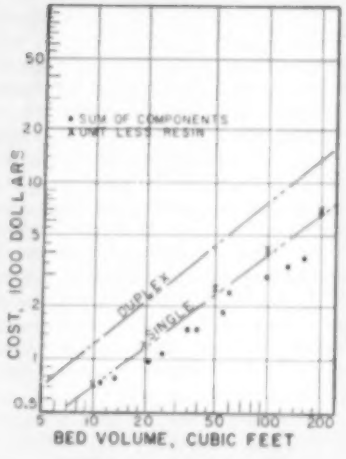

Fig. 8. Estimated costs for "empty" mild steel ion exchange units.

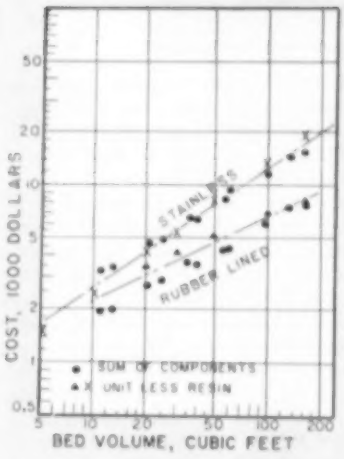

Fig. 9. Estimated costs (f.o.b.) for "empty" acid cycle ion exchange units.

costs of CATION EXCHANGE EQUIPMENT

This paper points up the vacuum which has existed for some time in the ion exchange literature and fills in many of the gaps. For the chemical engineer who is considering the installation of water-softening equipment or who is involved in fixed-bed ion exchange processes, the data supplied here can serve as a permanent guide in estimating rough costs and in the choice of suitable equipment.

R. F. Peak | Cascade Cartridge Company, Lewiston, Idaho
M. M. David | University of Washington, Seattle, Washington

The major use of ion exchange in the past was in the water-treating field. Hence, much of the available cost data for ion exchange materials and equipment has been reported on the basis of amounts, compositions, and rates of water to be treated. However, the rapidly increasing utilization of ion exchange in many other fields often requires examination of the feasibility of using various combinations of bed sizes, shapes, and flow arrangements; for this purpose it is desirable to have cost data available in more basic form and in larger quantity. Monet (*3*) and Mindler and Paulson (*2*) have made contributions in this direction, but considerably more data are necessary to permit satisfactory working estimates of ion exchange equipment costs. Accordingly, information of this type for cation exchange equipment has been compiled from the literature and obtained from ion exchange equipment manufacturers, and is presented in the following sections. In addition some data on anion exchange equipment and other costs have been computed and are also presented.

Companies furnishing data for the study are listed hereinafter. Each company contributed at least ten datum points, with the majority of companies furnishing many more than the minimum. In part, price information furnished by the companies represented working estimates, rather than exact costs. All the cost data have been corrected to an *Engineering News Record* Construction Index of 650 (Marshall Stevens Index of 190).

Notation

To simplify understanding, the following definitions are presented:

High-capacity resin. A sulfonated cross-linked polystyrene resin with a capacity of approximately 30 kilograins ($CaCO_3$)/cu.ft. when regenerated with 15 lb. of salt/cu.ft. Examples are Amberlite IR-120, Nalcite HCR (Dowex 50), Permutit Q, and Chempro C-20.

Medium-capacity resin. A sulfonated polystyrene resin with a capacity of approximately 20 kilograins/cu.ft. at a salt dosage of 5 lb./cu.ft. Examples are Duolite C-25 and Amberlite IR-112.

Synthetic zeolite. A synthetic, inorganic gel material of the sodium aluminosilicate family, with a capacity of approximately 15 kilograins/cu.ft. at a salt dosage of 6 lb./cu.ft. Examples are Nalcolite and Crystalite.

Solo-valve unit. An ion exchange unit with a multiple-port valve so arranged that flow of treated solution, backwash water, regenerant solution, and rinse water are all controlled by the single valve.

Multiple-valve unit. An ion exchange unit whose operation is controlled by valves located in the several pipe lines supplying the unit. The flows of feed, regenerant solution, rinse, and backwash require the operation in the proper sequence of more than one valve.

Single-bed unit. An ion exchange system consisting of one bed of exchange material, one regenerant make-up tank, and the necessary piping and valves.

Duplex-bed unit. An ion exchange system containing two beds of exchange material, one regenerant make-up tank, and the necessary piping and valves to permit operation of either bed while the other is being regenerated.

Bed volume. The volume occupied by the exchange material only.

Costs

SODIUM CYCLE OPERATION

The f.o.b costs of mild steel ion exchange units with sodium chloride regenerant are shown in Figures 1 and 2 as a function of bed volume. Each of the curves shown is based on more than 250 datum points. The data spread is only ±15%, even though variables of pipe diameter, bed diameter, and tank shell thickness were ignored. Solo-valve and multiple-valve units were indistinguishable in cost, and all units have been plotted on the same curves. The cost ratio of duplex- to single-bed units is 2:1 for either polystyrene or synthetic zeolite exchange materials.

Recommended flow rates for these units are generally 2 to 3 gal./(min.) (cu.ft.) for smaller beds and approximately 8 gal./(min.)(sq.ft.) of bed cross-sectional area for bed depths of 36 in. or more. However, some manufacturers state that flow rates up to nearly twice these will not materially reduce bed capacity. Most of the units have depth-to-diameter ratios falling within a prescribed range (see Figure 11). For depth-to-diameter ratios definitely below the range of common usage, an additional cost of 10% should be added to the values in Figures 1 and 2 because of the larger diameter tank needed. Conversely, a large depth-to-diameter ratio results in lower equipment cost.

The slopes of the cost lines in Figure 1 are approximately 0.86, which is higher than the usual scale-up exponent for equipment costs. This high value is due partly to the cost of the resin, which is essentially a linear function of the bed volume. In addition the increased complexity of the collection and distribution systems of the larger units tends to raise their costs. The difference in price of a high capacity polystyrene resin unit (Figure 1) and a medium capacity zeolite unit (Figure 2) of the same bed volume reflects not only the difference in cost between the two exchange materials but also the smaller tank size generally used with the latter material (see below). In addition a smaller regenerant make-up tank is required for a given volume of medium capacity exchange material than for the same bed volume of high capacity resin. The prices shown in Figures 1 and 2 are relatively close when compared on an exchange capacity basis.

Table 1.—Resin Prices as Quoted *

Resin	Price, Small lots 1-9 cu.ft.	Price, L.C.L. lots 10-200 cu.ft.
High capacity polystyrene resins:		
Chempro C 20, Amberlite IR-120, Dowex 50, Nalcite HCR, etc.	$30.00	$21.00
	32.00	26.00
Medium capacity resins and synthetic zeolites:		
Duolite C-25, Illco C 21, Ektorex, etc.	23.00	19.00
	25.00	22.00
Strongly basic resins:**		
Amberlite IRA-410 and IRA-400; Nalcite SAR, SBR; Duolite A-101, A-102; etc.	74.00	65.00
	88.00	75.00
Weakly basic resins:**		
Amberlite IRA-48, IRA 45; Nalcite WBR; Duolite A-2, A-7, A-114; etc.	47.00	38.00
	68.00	60.00

* Prices for greensands and sulfonated coals were not solicited because of their decreasing usage, especially in cycles involving fluids other than water.

** Data for prices of anion exchange resins were collected for calculations and estimates of the cost of anion exchange units. The material is incomplete and is presented as a guide only.

ACID CYCLE OPERATION

Cation exchange systems employing an acid regenerant generally use rubber-lined or stainless steel equipment, and the f.o.b. costs of such units as shown in Figure 3 are higher than those for sodium cycle units. All original cost data obtained for these types of system were for single-bed units, and the prices of the duplex units were computed from these original data. The curves for single-bed units are each based on less than twenty-five datum points. For comparative purposes the costs of standard sodium cycle mild steel units with high capacity resin are included in Figure 3.

The cost of duplex stainless steel units was computed by two methods: (1) by use of the duplex-to-single

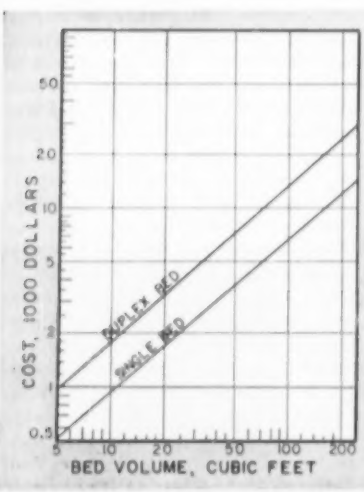

Fig. 1. Costs (f.o.b.) of mild steel cation exchange units, high capacity resin.

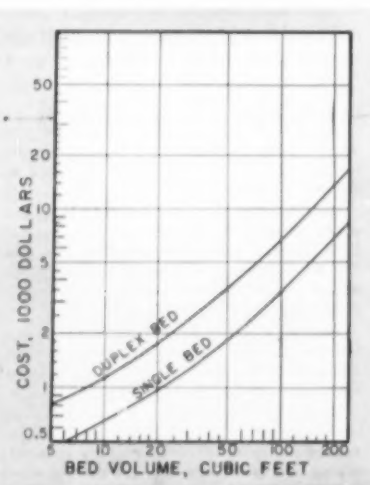

Fig. 2. Costs (f.o.b.) of mild steel cation exchange units, medium capacity synthetic zeolite.

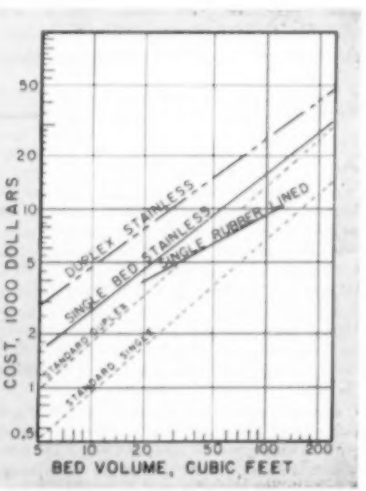

Fig. 3. Costs (f.o.b.) of acid cycle cation exchange units with high capacity resin.

bed ratio for standard mild steel units; and (2) by the addition of the costs of an extra tank, necessary valves, and resin to the cost of a single unit. The ratio method resulted in cost figures 3% higher for small units and 20% higher for large units. The curve shown is a compromise between the two sets of values.

The slope of the curve for single-bed stainless units is 0.78, which is closer to the common 0.6 scale-up factor and reflects the increased cost of the tank and pipes. As a rule of thumb, acid-cycle unit costs are often estimated at 1.75 to twice those of standard sodium-cycle units. Data of Figure 3 suggest this is satisfactory for rubber-lined units, but indicate that the factor should be 2.5 to 3 for stainless steel equipment.

INSTALLATION

Three types of installation costs for cation exchange units are shown in Figure 4. The lowest pair of curves represents the expense of hooking up a unit after it has been erected on a prepared foundation. The middle pair of lines presents the cost of erection plus piping hookup. The top pair of lines represents total installation costs, that is, all costs except freight, which must be added to the f.o.b. price to provide the total installed price. The lower pairs of lines are from values provided by equipment manufacturers and are based on approximately sixty datum points. The highest pair of lines was computed by the method of Lang (*1*), and the values thereon include cost of a foundation (as 5% of purchase cost plus freight) and transportation of equipment from railyard to job site, erection, and hookup (as an additional 17% of purchase cost plus freight). Lang's factor of 8% for supports and platforms has been considered as included in the purchase price of the units, since ion exchange units are commonly sold and shipped completely fabricated, with all necessary parts included. The cost of freight needed for Lang's method was taken as $27.50/1,000 lb. and was based on an 800-mile shipment.

Installation costs of Figure 4 can be added to the purchase prices of Figures 1, 2, and 3, to obtain installed costs exclusive of freight.

AUTOMATIC CONTROLS

Automatic controls on a cation-exchange unit are definitely an additional expense and are so quoted by manufacturing companies. Approximate prices for automatic controls for a single-bed unit are shown in Figure 5. These costs are for manually or time-clock initiated programming of the regeneration cycle. Completely automatic regulation of the exchange cycle, controlled by gallonage or effluent quality, will be more expensive because of the additional instruments and controls required. To a considerable extent, the cost of automatic controls is dependent on the pipe size used with a unit. Accordingly, dashed lines have been included in Figure 5 to indicate the pipe size commonly used with various bed sizes and the cost of control equipment for that pipe size.

Use of automatic controls on a duplex unit usually will require a duplication of the controls and valves for a single unit and also cross-over valves and interlocks. Hence, automatic controls for a duplex unit will probably cost from 2½ to 3 times as much as for a single-bed unit.

SMALL UNITS

A limited amount of cost data was collected for small deionizing units which perform both cation and anion exchange. These data are presented in Figure 6. The upper two curves are for units in which separate beds are used for cation and anion exchange; the lower curve is for monobed units. It should be noted that the bed size for the monobed units is the total bed size (with the cation exchange material occupying approximately half the total volume), but the bed size shown for the multiple-bed units is the size of each single bed. Generally the cation and anion exchange beds were nearly the same in size. All the small units were equipped with either a purity meter or automatic controls, the cost of which is included in the prices shown.

The installation cost for a small unit should approximately equal the cost of hooking up a single-bed standard unit, if the special unit is shipped completely assembled and mounted on skids. If the unit is not factory assembled, the installation cost would be that for the same number of standard beds of the same size.

ION EXCHANGE RESIN

The information collected on the costs of ion exchange materials is summarized in Table 1. The sale of ion exchange resins is an extremely com-

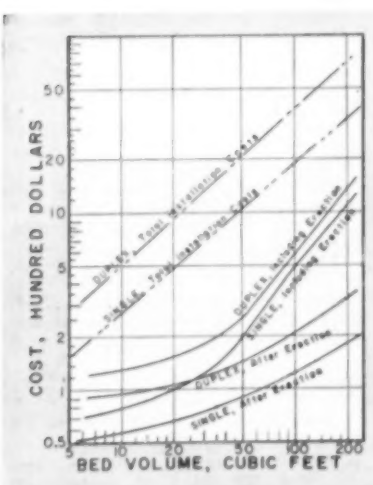

Fig. 4. Installation costs for cation exchange units.

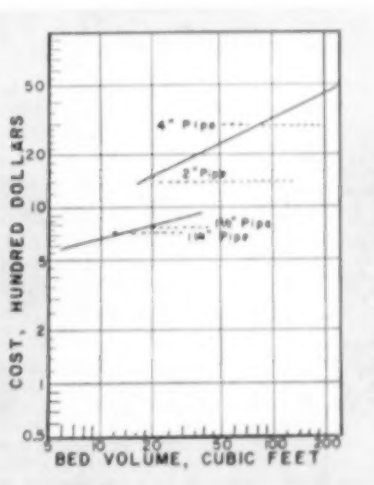

Fig. 5. Costs of automatic controls for single bed cation exchange units.

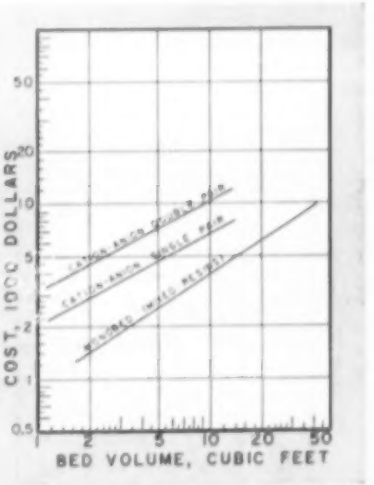

Fig. 6. Prices (f.o.b.) for small bed ion exchange units.

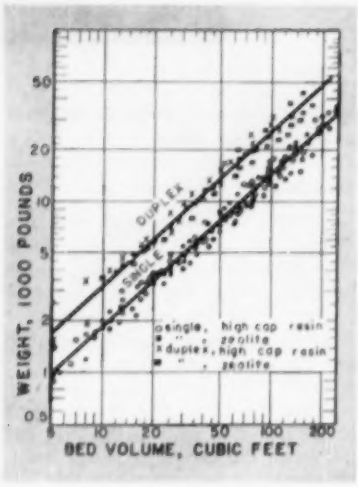

Fig. 10. Shipping weights of mild steel cation exchange units (complete with resin and bed support gravel).

petitive process in which the actual manufacturer usually markets his products through equipment and engineering firms. This is similar to the customary wholesaler - retailer - consumer system of distribution. Hence, even more variation in cost can be encountered than is indicated in Table 1. The prices quoted by the exchange material manufacturers for direct sale of small quantities are sometimes slightly higher than those quoted by the equipment sales companies for replacement resin.

DERIVED COST DATA

Data solicited from manufacturers in the present study were limited to cation exchange equipment. Because of the expanding interest in special ion exchange cycles, the preceding data have been used to compute costs of anion exchange equipment and of the equipment without resin. Computed costs for anion exchange equipment agree sufficiently well with published values (*2, 3*) to provide confidence in their use for preliminary cost estimates. However, the data presented in this section are intended only to serve as a preliminary guide.

Anion exchange equipment cost data are presented in Figure 7. These were obtained by adding the difference in cost between anion exchange material and cation exchange material to the cost of the corresponding cation exchange unit. The cost of the anion exchange resin was taken as \$71.50/cu.ft. and of the cation exchange resin as \$21.50/cu.ft. These prices are somewhat higher than the cost of the resins to the equipment manufacturer.

The costs of "empty" ion exchange units shown in Figures 8 and 9 were computed by two methods: (1) subtracting the cost of the resin from the cost of the unit given in Figures 1 through 3; and (2) adding costs of the valves, tanks, and regenerant make-up tank. In the second method it was not feasible to assign costs to the regenerant and feed distribution and collection systems, and accordingly the curves in Figures 8 and 9 have been drawn to favor the values computed by the first method.

BED WEIGHTS, DEPTH PER DIAMETER RATIOS

Information on shipping weights of cation exchange units is necessary for computing shipping charges and preparing foundations. This information is presented in Figure 10 for sodium-cycle units. The weight of an ion exchange unit varies considerably less for a given size unit than does the cost. The curves shown are for both resin and synthetic zeolite units, as all the data grouped well into the two lines given. Equipment filled with synthetic zeolite tends to have a slightly smaller shipping weight than resin-filled equipment. Synthetic zeolites are generally used in deeper beds and the units have a smaller free volume for backwashing. Hence, the tank size needed for a given volume of exchange material usually is smaller.

Specifications of the manufacturers were used to find the depth-to-diameter ratios of standard cation exchange units, as plotted in Figure 11. As referred to previously, values lying below the major grouping of points represent larger tank diameters with concomitant higher equipment costs. Standard tanks are customarily used for ion exchange equipment, and such tanks are usually available from stock in 6-in. increments of diameter. The designer of special cycles can select his bed diameter accordingly and take advantage of the lessened cost.

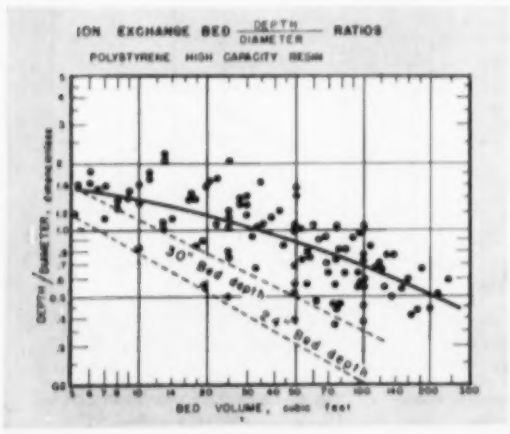
ION EXCHANGE BED DEPTH / DIAMETER RATIOS
POLYSTYRENE HIGH CAPACITY RESIN
DEPTH / DIAMETER, dimensionless
30" Bed depth
24" Bed depth
BED VOLUME, cubic feet

Fig. 11. Ion exchange bed depth per diameter ratios.

ENGINEERING

In the design of ion exchange equipment for special purposes, interpretation of rate and of equilibrium data requires judgment and experience. Most manufacturers of ion exchange equipment prefer to protect the reputation of their equipment by assisting the customer in preparing the design. The normal amount of custom design engineering represents an additional charge of 10 to 12% of the purchase cost. Special laboratory work to establish suitable resins and optimum operating conditions will add still further expense.

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Dorr-Oliver, Inc., Stamford, Connecticut
Elgin Softener Corp., Elgin, Illinois
Hungerford and Terry, Inc., Clayton, New Jersey
Illinois Water Treatment Co., Rockford, Illinois
Infilco, Inc., Tucson, Arizona
Los Angeles Water Softener Co., Inc., Los Angeles, California
National Aluminate Corp., Chicago, Illinois
Oshkosh Filter and Softener Co., Oshkosh, Wisconsin
Rohm and Haas Co. (Resinous Products Division), Philadelphia, Pennsylvania
Herbert Wolcott, Columbia, Missouri

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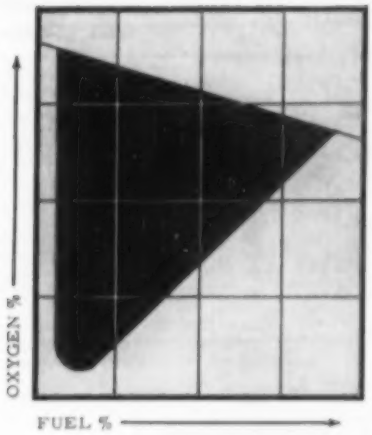

FLAMMABILITY LIMITS

for hydrocarbons at low pressures

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Certain aspects of the processing, handling, and uses of hydrocarbon fuels are controlled or dictated by one chemical property: namely, their ability to form explosive or combustible mixtures when added to air in the proper proportions. It is, therefore, important to know just what are these proper proportions, or flammability limits, from a very practical as well as from the theoretical viewpoint.

Almost all the ignition or flammability limits data reported in the literature were obtained in small vessels or tubes whose characteristic dimensions are given in centimeters. Ignition sources for this laboratory work were usually of the low-energy input type. In contrast to these conditions, the work reported in this paper was carried out in steel tanks of 12½-cu.ft. capacity, and with surface-discharge spark plugs as the ignition source.

Conclusions

Conclusions from the test program conducted with high-energy electric sparks as ignition sources are shown in Tables 2-5 as follows:

1. The ignition or combustion limits determined in these experiments with a 12½-cu.ft. tank and a high-energy ignition source, at room temperature, are wider than those reported hitherto in the literature. This is presumably due to the difference in experimental conditions, and is true for both nitrogen and carbon dioxide inerting.

2. Carbon dioxide is a more effective inertant than nitrogen on a volumetric basis, but less effective on a weight basis. Mixtures of the two gases are intermediate in effectiveness between the two pure gases.

3. The effect of increasing altitude, or decreasing the total pressure, is to narrow the ignition limits. Decreasing the pressure to values of 0.185 atm. or less also causes a marked decrease in the violence of the combustion.

4. The major effect of changes in temperature is to change the vapor pressure of the fuel.

5. The inflammation characteristics of fuels AN-F-58 (JP-4), AN-F-32 (JP-1) substitute (commercial kerosene), and commercial isopentane are essentially identical if vapor pressure differences are taken into account. Fuel AN-F-48 (100/130 grade) has the inflammation region shifted slightly toward higher fuel concentrations.

6. When liquid fuel is present in a fuel tank, that tank must be more completely inerted than when only a gas phase is present to be in the nonflammable zone.

Results and Discussion

Results of the spark-ignition test program are presented as a series of graphs showing regions where flammable and nonflammable mixtures exist. Table 1 summarizes the experimental conditions for each series of tests:

Coordinate System Used. All the graphs showing the ignition limits for fuel vapor-oxygen-inert gas mixtures are plotted on Cartesian coordinates with the volume per cent of fuel vapor as the abscissa and the volume per cent of oxygen as the ordinate. A straight line of negative slope labeled "atmospheric line" represents all mixtures of fuel vapor and atmospheric air. Lines parallel to this atmospheric line represent mixtures of fuel vapor, atmospheric air, and added inert gas. On the various graphs auxiliary scales are shown giving carbon dioxide and nitrogen concentrations.

Ignition Limits Curve. A curve, roughly U-shaped, with the ends of the U terminating on the atmospheric line is shown on each graph. This ignition limits curve is the line of demarcation between a region containing flammable mixtures and the region where mixtures are nonflammable. The left-hand branch of the curve is the lean limit (fuel lean limit) where the mixtures contain insufficient fuel to burn. The right-hand branch is the rich limit (fuel rich limit) where the mixtures contain too much fuel to burn. The bottom of the curve represents a region where there is too little oxygen for combustion.

Each ignition limits curve was determined by a series of "go" and "no go" experiments. At constant oxygen concentrations a "go" and a "no go" were obtained differing by not more than ½ of 1% in fuel vapor concentration. This, then, established the curve within narrow limits. Extending the

The work was sponsored by the Wright Air Development Center of the U. S. Air Force (Contract No. AF33(600)-17677). The Air Force's interest in the problem is in connection with the inerting of fuel tanks in military aircraft—the creation of a nonflammable mixture in the freeboard space of a fuel tank by the addition thereto of sufficient inert gas. The "blanketing" of storage tanks in industry with inert gas is a similar operation.

Table 1.—Spark Ignition Tests

Experimental conditions

Series No.	Fuel An-F-	Press. atm.	Temp. ° F.	Inert gas	Plug energy joules	Liquid phase present
1	58	1-0.07	70	N_2	3	No
2	58	1-0.7	70	CO_2	3	No
3	58	1, 0.46, 0.07	70	$6N_2$-CO_2	3	No
4	58	1	35	all	3	No
5	58	1	140	all	3	No
6	58	1	35	N_2, CO_2	6	No
7	58	1	140	all	6	No
8	48	1	35	all	3	No
9	48	1	140	N_2, CO_2	3	No
10	32	0.115	140	N_2, CO_2	3	No
11	x	1	70	N_2	3	No
12	58	1	35	N_2, CO_2	3	Yes

x = commercial isopentane.

See Tables 3-5 for inspection tests on fuels; fuel designation is by military specification.

experimental conditions to other variables such as different total pressure produced a family of curves which were then smoothed, but still consistent with the data.

When the family of curves had been drawn, cross-plots were made to obtain lines of fuel vs. pressure for constant oxygen. By smoothing these latter curves and then replotting the original curves from the smoothed curves, a more consistent set was obtained which still agrees with the data. The curves at different pressures tend to support one another, so that much of the original experimental uncertainty is eliminated with no additional experimental work.

The construction of a typical ignition curve is shown in Figure 2, after all smoothing operations, illustrating the results of this plotting procedure. This graph also shows the comparison of the results obtained in this investigation with those reported by Coward and Jones (*4*), their results being a complete summary of experimental work, mostly with smaller equipment and lower energy ignition sources.

The flammability (or ignitability) limits for AN-F-58 (JP-4) at 70° F. ±5° at pressures from 1 to 0.07 atm. (corresponding to N.A.C.A. standard altitude pressures in 10,000-ft. increments—see Table 2) with nitrogen and carbon dioxide inerting, and at pressures of 1, 0.46, 0.07 atm. with an inerting gas mixture of 6 parts nitrogen and 1 part carbon dioxide are shown in Figures 3, 4, and 5. All these graphs illustrate the same effect as the pressure is reduced of decreasing the area in which combustible mixtures occur. Not shown by the graphs, due to the method of assessing "go" and "no go" experiments is the difference in basic combustion phenomena. At the lowest pressures, in general, the combustion takes place with little or no pressure rise and appears as a blue, green, or blue-green slowly moving flame front; this is in the so-called "cool flame" region.

A comparison of Figures 3, 4, and 5 brings out the effectiveness of the three inerting gases used. Carbon dioxide, on a volume per cent basis, is the most effective inertant. There is little or no difference in the effect of changing the inertant on the fuel lean limit curve. However, the fuel rich limit is somewhat closer to the fuel lean limit for carbon dioxide inerting as compared to nitrogen inerting. The oxygen lean limit is affected the most, being approximately 10% for nitrogen inerting at sea level as compared to nearly 13% for carbon dioxide inerting under the same conditions. In all cases the gas mixture is intermediate in inerting effect between the two pure gases, and closely approximates nitrogen, the major component.

This comparison of the inerting efficiency is brought out more clearly in Figure 6. This graph is essentially a plot of the minimum quantity of oxygen at which combustion takes place as a function of altitude. It brings out the superiority of carbon dioxide as an inertant on the volumetric basis, a fact in agreement with earlier, small-scale investigations (*6*). Due to the difference in molecular weight (44 vs. 28) nitrogen is superior on the weight basis.

Figures 7, 8, and 9 again show the effect of changing the inerting gas, and of changing the temperature. Results are given at the three temperatures of 35, 70 ± 5, and 140° F. Attempts were made to obtain data at −65° F., but the vapor pressures of all the fuels were so low at this temperature that all mixtures were in the safe region, being outside the fuel lean limit. The same general relations existing among the three inerting gases at 70° hold true at the lower and higher temperatures.

The major effect of temperature is to change the vapor pressure of the

Table 2.—U. S. Standard Atmosphere (*3*)

Altitude ft.	Pressure lb./sq.in.obs.	Pressure atm.
0	14.70	1
10,000	10.10	0.686
20,000	6.76	0.459
30,000	4.36	0.296
40,000	2.72	0.185
50,000	1.687	0.115
60,000	1.047	0.071

Table 3.—A.S.T.M. Distillation of Fuels (*1*)

Per Cent Over I.B.P.	i-C_5 78° F.	AN-F-48 114° F.	AN-F-58 123° F.	Kerosene 327° F.
10	82.5	151	207	379
20	82.5	164	268	393
30	83.0	180	305	405
40	83.0	195	332	414
50	83.5	207	355	424
60	84.0	215	376	436
70	84.5	223	395	448
80	86.0	234	413	463
90	92.0	249	442	487
EP	97.0	283	495	527
Recovery—%	95	97	98	98
Residue—%	0	1	1.5	1.5
Loss—%	5	2	0.5	0.5

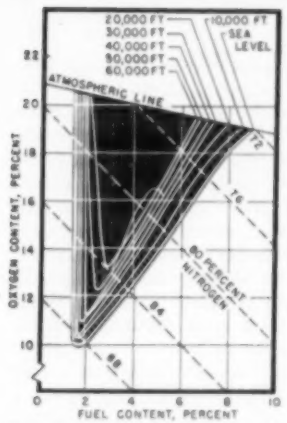

Fig. 3. Flammability limits: AN-F-58(JP-4) vapor with nitrogen inerting.

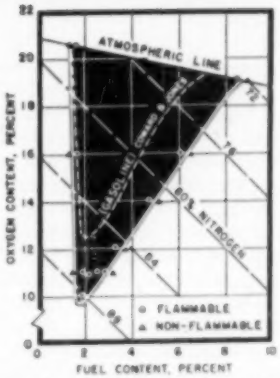

Fig. 2. Flammability limits: AN-F-58(JP-4) vapor; sea level with nitrogen inerting.

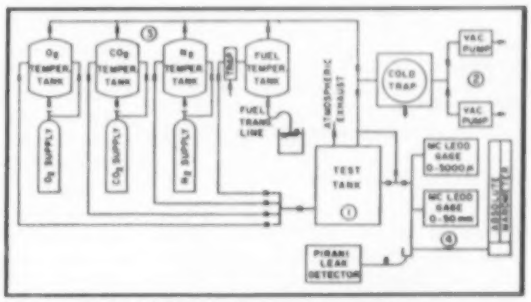

Fig. 1. Schematic diagram of test equipment.

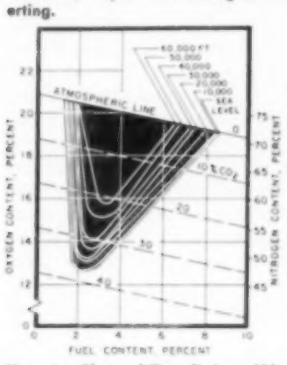

Fig. 4. Flammability limits: AN-F-58(JP-4) vapor with carbon dioxide inerting.

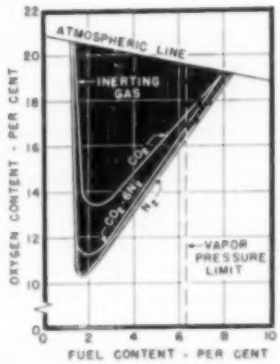

Fig. 5. Flammability limits: AN-F-58 (JP-4) vapor CO_2-$6N_2$ inerting gas, 70° F.

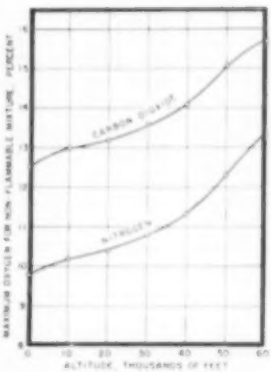

Fig. 6. Permissible oxygen concentration for CO_2 and N_2 inerted fuel-air mixtures. AN-F-58(JP-4) vapor.

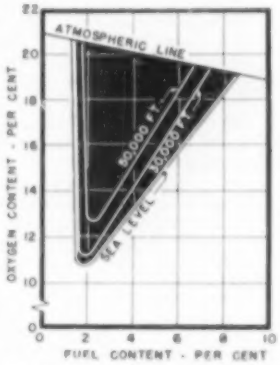

Fig. 7. Flammability limits: AN-F-58 (JP-4) vapor, 35° F., sea level.

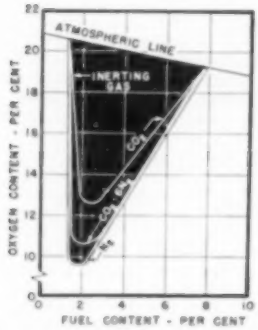

Fig. 8. Flammability limits: AN-F-58 (JP-4) vapor, 140° F., sea level.

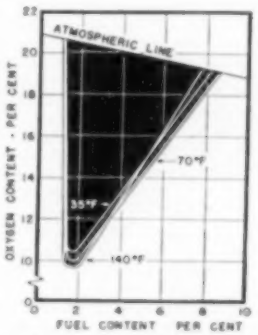

Fig. 9. Flammability limits: AN-F-58 (JP-4) vapor, N_2 inerting gas, sea level.

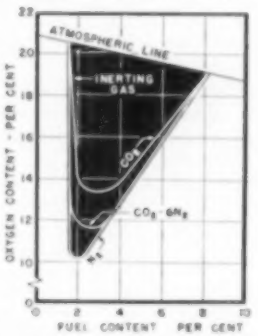

Fig. 10. Flammability limits: AN-F-48 vapor, 35° F., sea level.

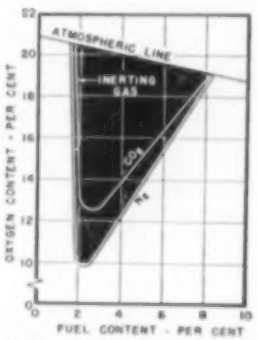

Fig. 11. Flammability limits: AN-F-48 vapor, 140° F., sea level.

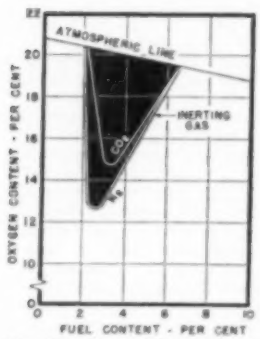

Fig. 12. Flammability limits: kerosene vapor, 140° F., 50,000 ft.

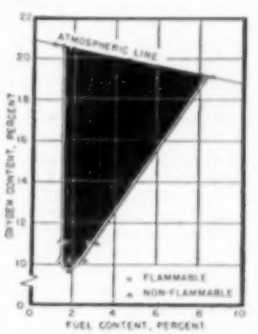

Fig. 13. Flammability limits: isopentane vapor, N_2 inerting gas, 70° F., sea level.

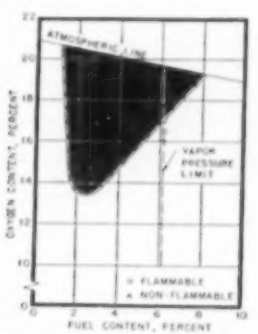

Fig. 14. Flammability limits: AN-F-58, 67% liquid filled, CO_2 inerted, 35° F.

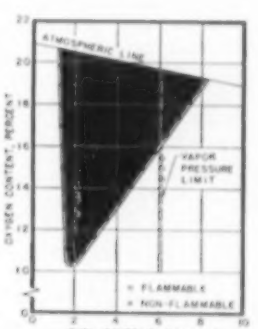

Fig. 15. Flammability limits: AN-F-58, 87% liquid filled, N_2 inerted, 35° F.

Table 4.—Reid Vapor Pressure of Fuels (1)

	lb./sq.in.
Isopentane	19.5
AN-F-58	1.85
AN-F-48	5.95
AN-F-32 subst.	0

fuel. In addition to making the taking of data at −65° F. impossible, it made impossible the obtaining of a complete fuel rich limit curve at 35°. Other effects of increasing the temperature, although relatively minor, are:

1. The fuel lean limit branches of the curve are essentially identical.
2. The oxygen lean limit (the bottom of the curve) is lowered to smaller values of total oxygen content by the 105° increase in temperature.
3. The fuel rich limit branch of the curve is moved to higher fuel concentrations by this same increase in temperature.

Results of using 6 joules stored energy on the condensers feeding the spark plugs, compared to the 3 joules used in the rest of this work, were demonstrated in series 6 and 7 experiments. In general, the results obtained with the higher energy input check those obtained with 3 joules stored energy within experimental accuracy and therefore are not given as graphs. There is a slight, but reproducible, tendency for the curves at 140° F. to show a widening of the rich limit as the composition approaches the atmospheric line. The conclusion from this work is that the quantity of energy delivered to the spark plugs is above the minimum ignition energy for both energy storage conditions.

Figures 10 and 11 show the effects of inerting fuel AN-F-48 (100/130 grade) with nitrogen, carbon dioxide, and the nitrogen-carbon dioxide mixture at 35 and 140° F. The curves bounding the region of inflammation are nearly identical to those obtained with fuel AN-F-58 (JP-4) under the same conditions except that they are displaced toward higher fuel concentrations by approximately 0.3% on the fuel axis. This shift may be due to a difference in the most volatile constituents of the two fuels, since it has been shown on a laboratory scale that the lightest hydrocarbons exhibit differences in combustion characteristics.

Inerting tests with kerosene (a substitute for fuel AN-F-32 [JP-1] which was not obtainable) were conducted at 140° F. with both nitrogen and carbon dioxide inerting at a pressure of 0.115 atm. Data are shown in Figure 12. The vapor pressure of the kerosene used was so low that it was impossible to get a flammable mixture with it at 1 atm. and 140° F., and only parts of the complete curve bounding the region of inflammation at pressures of 0.686 to 0.185 atm. inclusive. These two complete curves obtained with kerosene are exact duplicates of those for fuel AN-F-58 (JP-4) under the same experimental conditions. The conclusion to be drawn from this is that the most volatile constituents of these two fuels have the same inflammation characteristics, even though they differ in molecular weight and possibly in other ways from one fuel to the other.

Figure 13 gives the flammability limits of commercial isopentane (94% minimum purity), nitrogen inerted, at room temperature and sea level pressure, with 3 joules per spark plug stored electrical energy. Comparison of this curve with that obtained for

Construction and Operational Details Significant to Endpoint Determinations

Experimental Equipment

The experimental equipment consisted of: (1) test tank, (2) a vacuum-pump system, (3) gas and fuel supply system, (4) a temperature control system, (5) a pressure measuring system, (6) an ignition system, and (7) the program timer. A schematic arrangement diagram of the main units making up the equipment assembly and separated into functional groups is given in Figure 1.

Test Tank. The original test tank was a steel box 2½ ft. × 2½ ft. × 2 ft. made of ⅛-in steel plate, welded construction, reinforced with steel angle. It was protected against overpressure by a 6-in. diam. aluminum rupture disk (7) which burst at a nominal 20 lb./sq.in. gauge, which limited the pressure rise caused by combustion to values which could not damage the tank. A 1½-in. pipe line to the atmosphere was provided for expulsion of gases remaining at the conclusion of each test, and the tank was connected by a 2-in. pipe to the vacuum system. A manifold which could be called also part of the gas-supply system was attached to the tank, as was the pressure measuring system.

A 4-in. diam. Pyrex window in one side permitted visual observation or photography of flame phenomena.

A small stirring fan was installed inside the tank during the course of the tests when it was found that natural mixing was not sufficiently complete unless permitted to continue for impractically long periods.

Certain details regarding vacuum, gas-and-fuel supply, and temperature control systems used were omitted. Interested persons can obtain this information directly from authors.

Pressure Measuring System. The pressure in the test tank was observed during evacuation and loading by an absolute manometer and two Stokes McLeod gauges covering different ranges. These instruments were connected to the test tank; or through valves they could be made to indicate pressures in other parts of the system, for example, the tempering tanks. An Alphatron gauge was connected to the vacuum system primarily for the detection of leaks.

A Statham pressure pickup was installed in the test tank. This instrument was, in turn, attached to a DuMont type 304A Oscillograph so that pressure-time curves could be photographically recorded. The single sweep required on the oscillograph was initiated by the program timer.

Ignition System. The ignition source was a row of fourteen surface discharge spark plugs (2, 5) in the top of the test tank. Each spark plug was fired by discharging a 16-microfarad capacitor through it. The fourteen capacitors, together with the power supply, control circuits, and program timer were housed in a cabinet with safety interlocks and cutouts. For reasons of safety the power supply was energized by a push-button, so that it had to be manually actuated during the entire charging period. This button, when released in case of accident or danger, discharged all fourteen condensers through an internal shorting mechanism.

A high-voltage power supply with half-wave rectified output and continuously controllable voltage charged the capacitor banks. A Thyratron in each spark plug circuit acted as a switch, preventing the capacitors from discharging prematurely. The Thyratrons held as long as the grid bias was sufficiently negative. Operation of the program timer removed the grid bias from all Thyratrons simultaneously; this caused all spark plugs to fire.

Ordinary, automotive spark plugs were adapted for use in these tests by removing the ground-side spark electrode and filling the annular space between the center electrode and the plug body with Saureisen insulating cement. When this hardened, the surface was painted with Aquadag (a colloidal graphite suspension) and allowed to dry. The surface resistance of the spark plugs was adjusted to approximately 10,000 ohms by application or removal of Aquadag. In use, the plug resistance was found to increase gradually because of removal of the graphite film, leading eventually to failure of the plug to fire. It was found necessary to keep close check on the condition of the spark plugs in order to avoid collecting erroneous data.

Program Timer. The program timer consisted of a synchronous motor driving a shaft on which were mounted six ad-

fuel AN-F-58 (JP-4) shows that the two curves are identical within the limits of experimental accuracy. It seems to be standard practice in the petroleum industry to debutanize all aviation fuels, and to use isopentane, or a pentane mixture, in blending these fuels to vapor pressure specifications. These experimental data indicate that only the lightest fractions in a fuel are important in the behavior of that fuel toward inflammation in the fuel tanks or in storage since they make the major contribution to the total vapor pressure at temperatures below 150° F.

Results of those tests made with liquid fuel (AN-F-58 (JP-4)) in the test tank are shown in Figures 14 and 15. These tests cover both nitrogen and carbon dioxide inerting, and were made at 35° F. and at sea-level pressure. Attempts were made to perform these tests at 140 and at −65° F.; all these trials were "no go," presumably because in one case the fuel vapor pressure was so high that the fuel rich limit was exceeded, and at the other temperature the fuel vapor pressure was not sufficiently large to attain the fuel lean limit. Since these experiments involve liquid fuel at one temperature, the fuel vapor concentration is a constant; the percentage of inertant (or oxygen) is the only free composition variable. The amount of liquid fuel, whether 67 or 87% of the tank volume, had no effect on the results.

In all cases the test results show inflammation outside the curve previously determined without liquid fuel in the tank. These test points show that combustible mixtures are moved approximately to a fuel composition 1% higher, and to an oxygen concentration 1% lower, both of these percentages being based on the total mixture rather than on the individual component. Thus, with liquid fuel in the tank, a greater amount of inerting is required than when liquid fuel is not present. A possible explanation for this shift in the fuel-rich limit is that the basic phenomenon is different, that is, when liquid fuel is present, there is the possibility of having not only fuel vapor in the freeboard space in the tank, but also of having in that space a fog of liquid droplets. Wetting of the spark plugs in these tests, referred to previously, indicates the likelihood of the presence of such a fog. Suspensions of small combustible particles, either liquid or solid, in air are well known to be highly flammable.

Table 5.—Specific Gravity of Fuels

	Temp. ° F.	Sp.Gr.
Isopentane	74	0.6230
AN-F-58	70	0.7865
AN-F-48	74	0.7136
AN-F-32 subst.	70	0.7977

Method: Westphal Balance.

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justable cams operating microswitches. The microswitches triggered the sweep on the oscillograph for pressure measurement, fired the spark by removing the Thyratron grid bias, started and stopped a high-speed movie camera which was occasionally used to photograph phenomena inside the test tank. One microswitch turned off the timer motor at the end of one revolution.

Experimental Procedure

The experimental procedure used in this work is outlined in the following paragraphs, separated according to the equipment units involved.

Cold Trap. Before operating the vacuum pumps, it was necessary to lower the temperature in the cold trap to −70° F. or less. This was done by adding pieces of Dry Ice to the propylene dichloride bath jacketing the cold chamber of the trap.

Tempering Tanks. The fuel in the tempering tank was changed frequently in order that only the light fractions of fuel, representative of the vapor in an aircraft fuel tank, be used in the ignition tests. Fuel to be discarded was expelled from the tempering tank by opening the bottom valve and applying nitrogen pressure. The tank was then dried by blowing nitrogen through it, after which the fuel transfer line was capped and the tank and line evacuated to approximately 100 μ abs. pressure. The capped end of the fuel transfer line was then submerged in fresh fuel and the cap removed. The loading valve was closed before the entire fuel supply was drawn in, so as not to admit air. Air in solution in the fuel was liberated when the fuel was subjected to the low pressure of the fuel tempering tank, and removed by opening the vacuum valve momentarily. The pressure gauge on the fuel-tempering tank was observed several times daily to make sure that no air had leaked into the vessel.

The gas tempering tanks were loaded at the beginning of the tests by being pumped to a pressure of 100 μ Hg and then filled from their respective high-pressure bottles. The pressure regulators on these bottles were adjusted so that the gas pressure in the tempering tanks was maintained at about 50 lb./sq.in. gauge.

In tests at other than ambient temperature the tempering tanks were used to heat or cool the fuel and gases. This was accomplished by circulating a heat transfer fluid through the copper coils surrounding the tempering tanks.

Test tank. The test tank was evacuated to less than 100 μ Hg before loading. Components were then added in proportion to their final partial pressures in the resulting mixture. Since the vapor pressure was used as the driving force in loading the fuel, it was necessary to admit that component to the test tank first. Then the permanent gases were admitted to the test tank, the proportion being measured and controlled by observation of pressure. For safety, oxygen was always the last component added.

The test-tank-loading procedure was modified when liquid fuel was used. The liquid fuel, at room temperature for tests at or above room temperature, at or below the test temperature for work below room temperature, was pumped into the test tank through the rupture disk port by a hand-operated transfer pump. The rupture disk was then replaced, and the pressure in the tank reduced to that of the vapor pressure of the fuel; thus the loss of the more volatile constituents by the pumping-down procedure was minimized. The tank and its contents then were brought to the test temperature. During this partial evacuation of the tank, dissolved gases in the fuel were apparently released from it with sufficient splashing of the liquid fuel to wet the spark plugs and make them inoperative. Consequently it was necessary to replace the spark plugs with dry ones and repeat the evacuation. The permanent gases were then loaded in the usual manner.

Ignition. The condenser bank was then charged up to the desired point, the program timer set in motion, and the spark plugs fired.

Data. The composition of the gas mixture in the tank was obtained by the pressure (partial pressure) readings taken during the loading procedure. A pressure-time history of the events taking place was obtained on the oscilloscope screen which was photographed.

Results of any one test, on a "go" or "no go" basis were assessed by the operator by visual observation. The room containing the test tank was darkened before the test. Phenomena taking place in the tank were observed through the glass port in a mirror forming a simple periscope system. Any flame at all, no matter what its characteristic, was recorded as a "go."

Some early tests were photographed, but this proved to be actually inferior in many ways to visual observation.

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A Study of Anion Exchange Using a Monovalent Ion. DON R. KUEHN, Washington University. Prof. A. Rose, 68 pp. One copy for loan from University's library. (August, 1955.)

A Study on the Continuous Counter-Current Diffusion of Beet Sugar. HUNG HAN YANG, University of Michigan. Prof. J. C. Brier, 155 pp. One copy for loan from University's General library. Microfilm 1¼ cts./page. Abstract & conclusions published in "Microfilm Abstracts." (1955.)

MATERIALS OF CONSTRUCTION

The Adherometer Adhesion of Calcium Carbonate-Alkyd Coatings on Steel.* ARTHUR J. PERMODA, University of Michigan. Prof. L. L. Carrick, 89 pp. One copy for loan from University's General library. Microfilm 1¼ cts./page from University Microfilms, Ann Arbor, Michigan. (1955.)

The Catalytic Effect of Structural Materials on the Exchange of Deuterium from Steam to Hydrogen.* JOHN E. BIGELOW, M.I.T. Prof. M. Benedict, 189 pp. Not available on loan. (May, 1956.)

The Creep-Rupture Life at Uniform Elevated Temperature of Engineering Structures with an Initial Stress Gradient.* HOWARD VOORHEES, University of Michigan. Prof. C. M. Sliepcevich, 177 pp. One copy for loan from University's General Library. Microfilm 1¼ cts./page. Abstract & conclusions published in "Microfilm Abstracts." (1956.)

Effects of High Pressure Hydrogen on Metals.* DANIEL D. PERLMUTTER, Yale University. Prof. B. F. Dodge, 196 pp. Two copies for loan from Yale library. (June, 1956.)

The Nature of the Electrostatic Charging of Polystyrene. JOHN M. FLYNN, Case Institute of Technology. Prof. S. M. Skinner. One copy for loan from Case library. (June, 1956.)

Rate-Controlling Mechanisms in the Corrosion of Single Crystals of Zinc in Aqueous Solutions.* INDRA KUMAR ARORA, University of Washington. Prof. A. L. Babb, 128 pp. Three copies for loan from University's library. Photostats 30 cts./page; microfilm 1¼ cts./page. (October, 1956.)

PROCESSES

Aniline Furfural Stabilization of Iowa Loess.* JOHN B. SHEELER, Iowa State College. Prof. D. T. Davidson, 141 pp. Two copies for loan from Iowa's library. Photostats 35 cts./page; microfilm 2½ cts./page. (August, 1956.)

Battery Active Manganese Dioxide by Chemical Synthesis.* FRED P. BAUGHMAN, Montana State College. Prof. Lloyd Berg, 40 pp. Ten copies for loan from Montana's Dept. Chem. Eng. (June, 1956.)

Chemical Enrichment of the Manganese Content of an Ore from the Betty Baker Mine. GEORGE F. MEENAGHAN, V.P.I. Prof. P. H. Watkins, 162 pp. One copy for loan from V.P.I.'s library. (June, 1956.)

The Development & Characterization of Low Electrical Resistance Membranes & Their Application to the Silver-Peroxide-Alkaline Cell.* HAROLD H. BIEBER, Polytechnic Institute of Brooklyn. Prof. P. F. Bruins, 184 pp. One copy for loan from Spicer Library of school. (June, 1956.)

The Effect of Gamma Radiation on the Polymerization of Acetylene. KAMAL ABDA SHAIR, Yale University. Prof. R. H. Bretton, 400 pp. Two copies for loan from Yale's library. (June, 1956.)

The Effect of Pressure on Catalytic Cracking. FREDERICK C. FRANKLIN, University of Washington. Prof. L. N. Johanson, 172 pp. Three copies for loan from University's library. Photostats 30 cts./page; microfilm 1¼ cts./page from University Microfilms, Ann Arbor, Mich.

The Effect of Pressure on the Electrode-position of Metals. IRVING MOCH, Jr., Columbia University. Prof. H. B. Linford, 151 pp. Microfilm publication presently withheld. (May, 1956.)

Electrolytic Production of Acids & Bases. CHARLES J. HOMAN, Northwestern University. Prof. L. F. Stutzman, 115 pp. Not available on loan. Microfilm $5. + 1¼ cts./page. (June, 1956.)

The Irradiation of Polyvinyl Methyl Ether with Electrons & Gamma Rays to Form Elastomers. DICK DUFFEY, University of Maryland. Prof. W. J. Huff, 140 pp. Two copies available on Inter-library loan. Microfilm 1¼ cts./page. (1956.)

Ozonation of Cyanides.* KRISHNA KUMAR KHANDELWAL, Syracuse University. Prof. C. S. Grove, Jr., 151 pp. One copy for loan from University's library. (June, 1956.)

Simultaneous Reaction & Distillation in a Catalyst-Packed Column. GEORGE C. SZEGO, University of Washington. Prof. L. N. Johanson, 105 pp. Three copies for loan from University's library. Photostats 30 cts./page; microfilm 1¼ cts./page. (May, 1956.)

A Study of Alkyd-Silicone Coatings. AZIZ F. ABDUL KARIM, Purdue University. Profs. R. N. Morgan & R. N. Shreve, 127 pp. One copy for loan from Purdue's library. Photostats 20 cts./page; microfilm 1¼ cts./page; Ozalid 4 cts./page, plus postage. (January, 1956.)

A Study of Methods for the Production of Bromotrifluoromethane & Dibromodifluoromethane. CHARLES R. FINCH, University of Maryland. Prof. A. H. Cooper, 168 pp. Two copies for Interlibrary loan. (1955.)

What ENGINEERS *expect from* INDUSTRY

The extraordinary growth of the engineering profession since World War II has brought with it some real growing pains. One of the areas where stress has been felt most acutely is in the relationship between engineers and management. In order to explore some dimensions of these relationships in industry today, the Opinion Research Corporation conducted comprehensive interviews with more than 800 engineers in the following five major industries distributed in industrial centers from coast to coast: aircraft, automobile, electrical machinery, petroleum refining, and steel. Also included in the survey were seven homogeneous engineer groups with leading American companies. These engineers are industry's qualified professional, technical, and scientific personnel holding nonmanagerial positions; they are well educated, and highly articulate; and they know what they expect from management. Herein we present the specifics, many of which come down to human relations factors.

Hugh L. Rusch and Joseph R. Gaeke | Opinion Research Corporation, Princeton, New Jersey *

The growth of the engineering profession results, of course, in expanding career opportunities, and the engineer recognizes this fact. In answer to the question: Is engineering as a career more or less attractive than it was ten or fifteen years ago? Approximately 69% of engineers answer that it is; only a small minority of 14% reply that it is less attractive (Figure 1). Among the men of long experience—those forty-five years of age and over who remember an earlier era—a majority of 80% say engineering is more attractive today than ten or fifteen years ago. This opinion is the result of enlarged horizons in engineer thinking and of the greater professional and material recognition engineering accomplishments are bringing.

Table 1.—How Engineers Vote on a Series of Statements about Their Jobs

	True %	Not true %	No opinion %
"Engineers are given too much routine work"	77	21	2
"Pay not high enough compared with other positions requiring same or less ability"	76	19	5
"Engineers are not kept properly informed of company policy"	61	37	2
"Too little chance to use creative abilities"	45	53	2
"The company does not help to further his education"	44	54	2

Table 2.—What Job Values the Engineer Likes Most

	% naming this item
Interesting work	74
People he works with	63
Security	40
Employee benefits	40
Amount of responsibility	37
Immediate supervisor	35
Working conditions	32
Chances for advancement	31
His pay	23
Credit for good work	18
Opportunity for further education	12
Personal interest company takes in him	8

Clerical Requirements Abhorred by Engineer

On the other side of the ledger there are pertinent objections. Topping the list of the engineer's spontaneous complaints is the charge that he is forced to fight his way through a jungle of administrative red tape and onerous routine. His creative energies and productive drives too often ebb away in the struggle with clerical detail. In another part of the interview where they were asked to state whether a series of individual statements about their jobs was true or false, 77% agreed that "engineers are given too much routine work." (See Table 1.)

Engineering—A Fairly Paid Profession?

Second in his list of complaints, as is also indicated in Table 1, is the question of pay. As noted here, 76% of the engineers interviewed say their pay is not high enough compared with other positions requiring the same or even less ability.

More than four engineers out of every five who participated in the survey are earning $6,000 a year or more. As a group, therefore, the engineers stand fairly high on the national income scale, but their testimony about salary makes it clear that management's pay policies fall considerably short of fulfilling the engineer's expectations. When talking about his pay, the typical engineer does not use the vocabulary of the financially oppressed such as "I'm not making a living wage"; "can't make ends meet," etc. Instead, he concentrates on salary injustices in relation to his experience, and makes comparisons with what other groups on the company payroll are earning.

To many engineers, the only way to keep climbing up the financial ladder is to move over onto the management rungs. A common observation is: "The salary curve flattens out for experienced engineers except in solely management positions." To the engineer, *pay* seems to be almost as important a status symbol as it is a means of acquiring the material goods of life.

The specific comments about the engineer's pay in relation to other professions and trades are not confined to a mere handful of engineers. They are voiced by the great majority.

Clearly, today's engineer expects management to do some basic recalculating if only in response to the law of supply and demand. In one company where dissatisfaction with pay is especially keen, some engineers come right out with it. Their most effective way of getting a raise, they admit, is by taking a higher paid job at another company in the area; after a decent interval, they can return to their former company at a "pirate" rate.

Yet such practice is not characteris-

* Mr. Rusch is Vice-President and Mr. Gaeke is Research Director of Opinion Research Corporation.

tic of the engineer and makes him feel uncomfortable. He is not so intent on making a higher salary per se as he is on gaining the kind of recognition his background qualifications and professional contribution deserve.

Desire for Professional Recognition

Like all highly educated men with a sense of dedication to important work, the engineer wants and expects such recognition. Threading through many of his frustrations is the belief that management does not give enough recognition to his professional status nor is such recognition desired for the personal gratification it may afford. His attitude toward his job is inherently creative; his skills and knowledge are laboriously acquired; the demands upon him for keeping abreast of the technological revolution are growing. Furthermore, he has a profound consciousness that the future of industrial society may very well lie squarely in his hands. Yet it is on the score of professional recognition management draws the most consistent criticism from the nation's engineers. This criticism, with an insistent, almost angry, undertone, runs the gamut from feuding between production and engineering to crowded working conditions. Further criticism is directed against shoulder-shrugging superiors, status symbols such as parking privileges, and the feeling of being shoved around.

Working in the Dark

Third in the list of criticisms about his job, as is brought out in Table 1, is that 61% say that engineers are not kept properly informed of company policy. In other words, they are not advised of what is happening outside their own work.

The Engineer and Collective Bargaining

Top A.F.L.-C.I.O. leaders have been spearheading appeals to engineers and scientific personnel to "join up with us." These drives have caused management considerable concern. The major engineering societies have been exploring the subject with their memberships. Unionization is, *from certain angles*, a symptom of a morale deterioration among professionals that can interfere seriously with productive work spirit.

Whereas engineers can and do join unions or comparable associations, to date the results of these organizational efforts have been spotty. Some professionals have been swept into collective bargaining units along with technicians and other nonprofessionals. More commonly, the professionals have set up independent "associations" for collective bargaining. The principal national body of the independents is the Engineers and Scientists of America—the E.S.A.

Leaders in the top tier of industry's engineers have spoken out plainly against unionization of professional people. But the fact is that scientific personnel employed by a number of the nation's outstanding corporations have elected to unionize at some locations and to engage in collective bargaining with management. Hence it is pertinent to inquire about the current thinking regarding unions and collective bargaining across the board in the engineering profession.

In order to obtain first some indication of how many of the engineers in the survey have current experience with professional unions, the question was asked, "Do any engineers where you work belong to an engineer's union or council or association for similar purposes?" A large majority of 71% say no, 16% yes, and 13% say they don't know.

When they were asked what they thought about joining a union or a comparable organization, the great majority reject collective bargaining as the way to advance the cause. Many replied with considerable heat that they can take care of their own interests. The idea of unions for their group goes against the grain of the engineer's professional pride.

Because of the importance of the subject, the engineers interviewed were given the opportunity to express their views on four basic statements about unions, pro and con, and the results are indeed very enlightening. One of these statements, summarized in Figure 2, was:

> **Because companies employ large numbers of engineers today, the individual engineer needs some sort of union or similar association to represent him.**

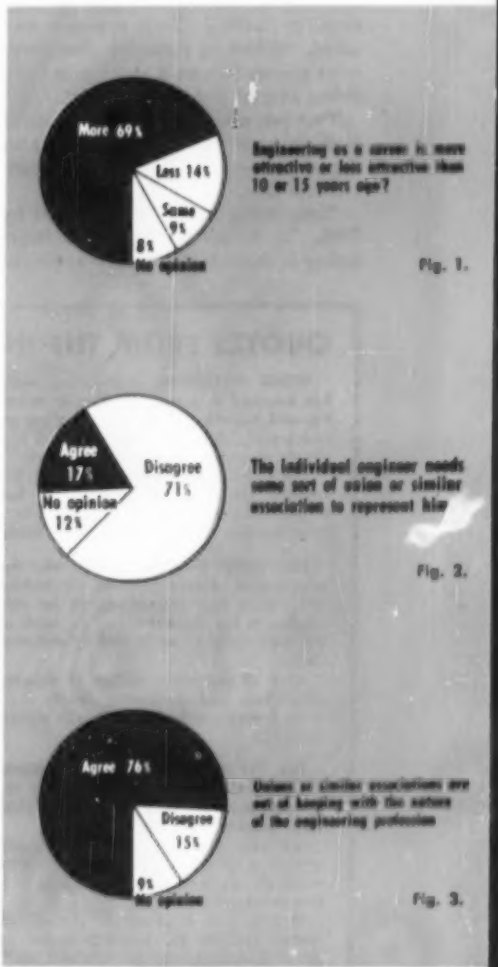
As indicated in the figure, 71% disagree whereas only 17% agree; 12% have no opinion.

Posing the question another way: "Do unions or similar associations tend to be out of keeping with the nature of the engineering profession?"

Again strong support is expressed for the belief that labor unions are intrinsically out of gear with engineers' professional and individual values. As observed in Figure 3, 76% agree with this, and only 15% disagree.

It is worthy of comment that among the engineers who are members of one or more of the principal professional societies, only 14% favor a union, whereas among the nonmembers, 21% do.

Also, among those who rate excellent relationship with managements, only 10% favor a union for engineers, whereas among those who claim strained feelings or only fair relationship, 25% favor a union.


More 69%
Less 14%
Same 9%
8%
No opinion
Engineering as a career is more attractive or less attractive than 10 or 15 years ago?
Fig. 1.
Agree 17%
Disagree 71%
No opinion 12%
The individual engineer needs some sort of union or similar association to represent him
Fig. 2.
Agree 76%
Disagree 15%
9%
No opinion
Unions or similar associations are out of keeping with the nature of the engineering profession
Fig. 3.

As might be expected, the chief spark for unionizing is the appeal, "more pay." This reason for unionizing is cited more than three times as often as any other reason. Although pay is not the main key to engineers' job satisfaction, "injustice in pay" can and is often whipped up as a powerful rallying force for the union idea.

Also worthy of particular comment is the fact that the sentiment for unionization of engineers varies con-

siderably from company to company. Among the seven groups of engineers within widely separated leading companies, the vote of these groups in favor of a union varied all the way from 11 to 41%, indicating that management's handling of the engineer can be an important factor in his thinking about the collective bargaining issue.

With reference to specific job values in the engineer's mind, one test employed to gain further insight into his thinking was an evaluation of twelve job ingredients, including many on the nonmaterial side of the job package listed in Table 2. Each engineer was asked, "Which of these job characteristics do you like most about your job? Select several if you wish."

Two job values (see Table 2) stand well above all the others, intrinsic in the work itself and in the people associated with the work.

"Interesting work" was selected by 74%. To be sure, a job that's interesting is important to every employee group, but outstandingly so for engineers as indicated by comparative data from parallel tests; among a national sample of industry's white collar employees, only 42% pick "interesting work" compared with this 74% vote among engineers.

Also high in importance in job values picked by the engineers were their associates (a 63% vote). Third, but some twenty points lower, was "security"—chance to keep your job. "Pay" comes up as ninth on the list, named by 23%; this statistic again brings out that engineers do not put undue stress on the material rewards of their profession. Other factors which come ahead of pay, beyond those already cited, are "responsibility given," "supervision," and "working conditions." This again bears out a significant finding based on a great many employee attitude studies which were made across the nation over a period of nearly twenty years: Pay is and always will be an important job ingredient, but it is not the uppermost factor in job satisfaction. In community after community, we have found that the company that pays the highest wages is not necessarily the place where people like most to work.

WHO ARE THE ENGINEERS IN THIS SURVEY?

The Opinion Research Corporation Survey included only engineers employed by industrial companies in nonmanagerial positions. Technicians were excluded. Thus, this study reflects the views of men in primarily engineering assignments on company payrolls.

QUOTES FROM THE INTERVIEWS

WIDER HORIZONS: Engineering work has assumed a greater position in industry, and therefore, there is greater opportunity to do significant, creative work and obtain greater compensation.

The technological advancement of our country has been very rapid and has brought out the need for specialists in a great number of new engineering fields.

TOO MUCH ROUTINE!: I like least the innumerable details involved in writing and editing departmental reports for submission to top management . . . much of this work could be performed by statistical clerks.

Much of my work consists of detailed calculations and accounting details . . . There is simply nobody to delegate clerical chores to.

THE ENGINEER AND THE MILKMAN: The charwoman in our section is paid $80 a week; a starting engineer is paid $100-$120, depending on degree, etc.

My main gripe is pay scales—a truck-driver, a milkman make approximately equal money with no requirements of a formal education.

In this area a carpenter, one of the lowest paid of the building trades, receives $540 a month for a 40-hr. week. Compare this with the starting salary of a B.S. or M.S. engineer!

A LOVE OF LABOR: Engineers want most of all to be given a job of wide scope which taxes their abilities, their creativeness or talent—as you wish. A heavy work load of this nature is refreshing. A boss who can teach and will teach is an inspiration.

Engineers, as they say, are a strange breed of cat. Money is not their primary goal. What they want most of all is professional recognition. They are willing to devote their whole lives to study and work because they enjoy what they are doing.

DEPARTMENTAL RIVALRY: I do not like the rivalry between production and engineering; it's useless and expensive. I do not like the production people telling engineers whether or not they will accept a change. If an engineer proposes a change, it is usually after giving it much consideration.

The company regards engineers as a necessary evil, in a friendly way, of course. Management thinks the point of view of engineers is typical of the species and must be tolerated.

MANAGEMENT REMISS: I feel that the nature of my work and the tenure I have should give me more recognition from my superiors, but I get little credit for the work produced.

Management ignores our individual complaints until the howls are widespread.

In this company the prestige of engineering is near the bottom compared to manufacturing and sales.

We should have at least equal parking privileges with employees getting the same pay in purchasing, sales, finance, and personnel departments.

There is much time wasted in meetings due to big shots' conjectures on items they know too little about; too many Chiefs, too few Indians! Contempt is shown by nonengineering brass to cold facts developed by engineers.

UNIONISM: Most engineers are sufficiently independent thinkers to object to surrendering totally their personal responsibility for decisions which affect their lives and their working conditions.

The make-up of an engineer and the unionization of engineers seem incompatible. Unions reduce incentive by placing all on a common level of mediocrity.

Individual ability, ambition, and foresight are the engineer's best help, not unions. Unions will advance the cause of the average man, but penalize the aggressive.

Conclusions

Each company must seek its own special solutions to the problems faced by the engineering group. Where companies reckon with the individual psychology of the engineer and his special talents and needs, there is little doubt that management can go a long way toward bringing out the technical man's full creative response.

That there already exists a solid basis for building a better and more productive relationship between the engineer and management cannot be doubted. Although engineers show their native analytical ability in pointing out the flaws in management's handling of their problems, most of them return a favorable over-all verdict on the companies with which they are associated. Approximately seven engineers in ten say their company is "above average" or "one of the very best" as a place to work compared with other companies they know about, and their satisfaction with their present job is also relatively high.

Stripped to the bone, this survey indicates that two things are needed if both engineers and management are to make the most fruitful use of their productive relationship. Management must understand what the engineer expects, and know that his expectations are high. But the engineer must also learn to view his own job as management is forced to see it, that is, in the light of the complex requirements of the whole business which must prosper as an organization if its various members, including engineers, are themselves to grow in stature and attain happiness in their work.

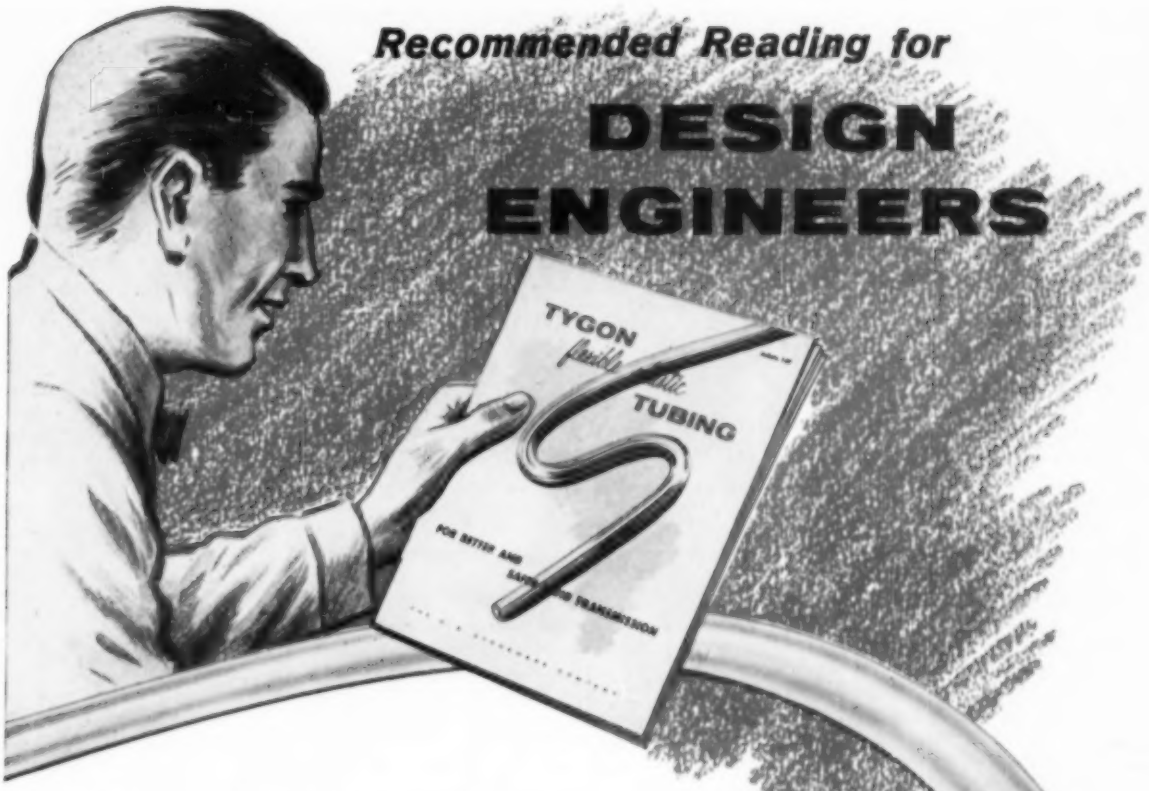
ERRATUM

In the article, "Wisconsin Process System for Recovery of Dilute Oxides of Nitrogen" (November, 1956, page 488) by E. D. Ermenc, the kinetic equation in the middle column of the page contains a typographical error. It should be as follows:

$$-\frac{dp_{NO}}{dt} = k(p_{NO})^2 p_{O_2}$$

Recommended Reading for

DESIGN ENGINEERS



In the pages of this booklet are data every design engineer will want to have when faced with piping problems involving fluids or gases.

Where and how flexible plastic tubing can be used most effectively; how plastic tubings can differ even within a single family of resins; how to select the type and formulation to fit your requirements.

Specifically, of course, it deals with Tygon flexible-plastic Tubing — the flexible plastic tubing most widely used in laboratories, hospitals, food and beverage plants, and in the chemical industries.

Detailed tables outlining the physical, and chemical characteristics of the various standard Tygon formulations, complete table of chemicals to which the tubing is resistant, methods of assembly and cleaning, data on working pressures and temperatures . . . facts which simplify the problems of any engineer . . . are yours in this free booklet.

Write for it today. Ask for Bulletin T-97.

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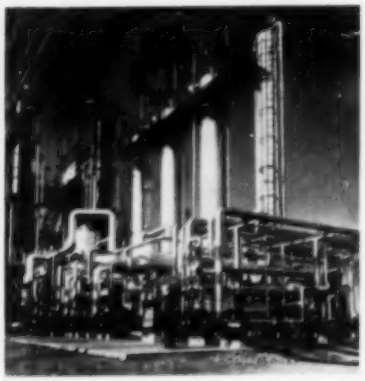
U. S. STONEWARE
AKRON 9, OHIO

MAJOR ISOCYANATES PLANT GOES ON-STREAM

National Aniline Division's (Allied) new multi-million-dollar organic isocyanates plant goes on-stream at Moundsville, W. Va.

New plant expected to give boost to development of commercial urethane applications.



The Girdler gas reforming unit at Moundsville, which forms a major part of the facilities.

Successful start-up of the process industry's newest and most modern isocyanate facility, constructed in record time at National Aniline's plant site at Moundsville, 70 miles from Pittsburgh, is expected to assure a stable, large-volume supply of economic isocyanates for the industry.

Fast becoming an important class of synthetic organic chemicals, isocyanates have a large potential in the manufacture of synthetic rubbers, resins, plastics, adhesives, surface coatings, and fibers. Other fields will undoubtedly open soon based on the unique reaction characteristics of isocyanates. At present, attention is centered mainly on the booming field of urethane foamed plastics.

A completely integrated plant, it utilizes a gas reformer unit to produce carbon monoxide and hydrogen from natural gas. The hydrogen is then used for the catalytic reduction of nitrated toluene to diamine. The diamine is phosgenated, with phosgene produced by reacting the carbon monoxide from the reformer with chlorine from the Solvay Division's facilities at Moundsville, to produce the diisocyanate. All materials used come from within the Allied group of companies.

The new plant takes over major production from the interim plant at Buffalo, but the Buffalo plant will continue to produce new isocyanates developed at National's Buffalo Research Center.

Anticipating large growth in the market, the Moundsville plant has been built for easy and substantial expansion by National's engineers who designed and built the plant.

Construction has begun on a new acrylate ester plant of Celanese Corp. Located in Pampa, Tex., the new plant will have a capacity of 15 million pounds of acrylic acid esters per year, is expected to go on-stream late in 1957. □

First bale of new man-made rubber that exactly duplicates tree rubber was produced recently in this new Goodrich-Gulf Chemicals pilot plant at Avon Lake, O. Called Ameripol SN, the new rubber is Goodrich-Gulf's entry in the battle to synthetically duplicate natural rubber which is still the only type of rubber that can be used in many applications, particularly protective linings or coverings against chemical corrosion, and heavy duty truck tires. So far, Ameripol SN has passed all tests for truck tires, may well replace crude rubber in chemical linings.

Exclusive option has been taken on an Australian process for separating hafnium from zirconium chloride by U. S. Industrial Chemicals Co. division of National Distillers. The process, developed by Commonwealth Scientific and Industrial Research Organization of Australia, is now in pilot plant stage at U.S.I.'s Cincinnati research labs. If it proves commercially feasible, U.S.I. plans to exercise its option and buy world-wide patent rights, excluding only Australia.

The process reduces considerably the cost of separating hafnium from zirconium, mandatory in nuclear applications of zirconium which at present form the major applications, by eliminating the cumbersome extraction step in current and projected commercial production. It will be far less expensive than other methods which rely on a series of chemical steps to remove the hafnium. □

Gulf Oil Corp. has purchased options on more than 3,000 acres of land at Charleston, S. C., for a possible future oil refinery. A major attraction of the area is the gigantic industrial water project at nearby Bushy Park. □

A contract to design, engineer and construct a phosphate fertilizer plant for Coastal Chemical Corp. at Pascagoula, Miss., has been awarded to The Fluor Corporation. Mississippi's first integrated phosphate fertilizer plant, the installation will include a 75 tons/day phosphoric acid unit, a 350 tons/day granulated ammonium phosphate fertilizer unit, and will be the first plant in the U. S. to use the St. Gobain process developed in France. Cost is some $2 million, construction will begin in April, will be completed in January, 1958. □

A new half-million-dollar amino acids pilot plant is now in production at Dow Chemical. Marking Dow's increased activity in the field, the new facility will be able to produce all 18 amino acids presently sold by Dow, but in actual practice only 15 will be produced, the other 3 already being produced in commercial quantities. □

TURN FOR MORE NEWS ON

INDUSTRY	page 54 et seq.
NUCLEAR	page 90
RESEARCH	page 107
INSTITUTIONAL	page 110
OVERSEAS	page 119

Alnico permanent magnets power the new Eriez Ferrotrap, visible above at left of the paper. Trap body and cover plate are Type 316 stainless chromium-nickel steel, non-magnetic and easy to clean.

How Alnico guards products and machines ...traps tramp metal continuously

This operator holds a collection of nails, paper clips and other ferrous contaminants. All were removed by the Eriez Ferrotrap from liquid caramel being pumped through a candy plant pipeline.

Keeping hot, viscous caramel free of tramp iron is an obviously difficult task. But a new Eriez unit, aptly named the Ferrotrap, does this sort of job with multiple rods or "fingers" containing Alnico permanent magnets.

No need for electromagnets, current and accessories, because at temperatures up to 850°F the powerful, life-time magnetic strength of a high nickel alloy . . . Alnico . . . assures positive trapping of iron particles. Even nuts, bolts, and the like.

Units that protect not only product purity, but also filters, mixers, pumps and other costly equipment are made practical by the powerful magnetic properties of Alnico, an aluminum-nickel-cobalt-iron alloy.

Nickel . . . an essential element in Alnico . . . improves hundreds of other alloys utilized in industry. So if you have a problem involving metals, consult us on the use of nickel or nickel alloys. But if you wish further information about the Ferrotrap, write Eriez Manufacturing Company, Erie 6, Pennsylvania.

INCO TRADE MARK **THE INTERNATIONAL NICKEL COMPANY, INC.** 67 Wall Street New York 5, N. Y.

ENRICHED URANIUM NOW PRODUCED BY PRIVATE INDUSTRY

The world's first production by private industry of enriched uranium for use in generating commercial electric power has recently gone on-stream at the new Hematite, Mo., plant of Mallinckrodt Chemical Works.

Operating as a "custom-shop" under license from AEC, Mallinckrodt's Hematite plant is now producing uranium dioxide enriched in U-235 and manufactured to meet individual customer specifications. Mallinckrodt does the manufacturing of the enriched oxide only, the customer fabricates the material into shapes that will be most useful in the core of atomic reactors.

Mallinckrodt buys enriched uranium hexafluoride from AEC, turns it into two grades of uranium dioxide, has facilities for converting all degrees of enrichment into the oxide. Already the company has produced material for General Electric, General Nucleonics, Westinghouse, and other companies involved in commercial nuclear energy work.

The Process

Uranium hexafluoride gas is purchased in cylinders from Oak Ridge and the gas is heated with an electric blanket and vaporized into water where it hydrolyzes to form HF and uranyl fluoride. The uranyl fluoride is then precipitated as ammonium diuranate with aqua ammonia, filtered, washed, and dried.

By thermal decomposition the uranyl fluoride is decomposed to U_3O_8 and the U_3O_8 reduced with hydrogen to uranium dioxide.

The end product this way is the ceramic grade of uranium dioxide. By additional processing the company also produces the sintered grade.

A major facet of the process, developed at a pilot plant in Mallinckrodt's main St. Louis works, is that the higher the enrichment, the less oxide can be produced at one time, since there is danger of exceeding the critical mass of the enriched material. To overcome this danger only a few pounds a day of highly enriched material can be handled.

In addition the entire process equipment line must be cleaned after each batch has been processed.

Mallinckrodt's engineers have developed a number of elaborate precautions that permit safe control of radiation, dust and materials. All exhaust air is put through special dust collectors to insure complete removal of uranium dust, not only for product recovery, but to prevent air contamination. All process water is thoroughly treated prior to discharge.

In this bay highly enriched uranium dioxide is manufactured at Mallinckrodt's new Hematite, Missouri, plant.

Future

Since the highly enriched material is only leased from AEC, the oxide production cannot be stockpiled but must be contracted for by the ultimate user and given to Mallinckrodt for processing. This is one reason why the plant is operating as a custom shop.

Mallinckrodt hopes for a large business but expects a slow rather than a fast growth, depending on the development of industrial atomic reactors and the nuclear industry in general.

Another unit in the 17-plant network of Stauffer Chemical Co.'s agricultural chemical plants has been established at Phoenix, Ariz. As in the case of the other Stauffer units, the Phoenix project will operate as a relatively autonomous regional enterprise. □

Carbide and Carbon Chemicals will build this multi-million dollar engineering building at South Charleston, W. Va. to provide space for more than 500 engineers engaged in designing new equipment and new plants for the company's continuing expansion program. Ultra modern in design, the new building will have an unusual number of offices with wood paneled walls running to the ceiling to provide quiet for the engineers. □

Adoption of automation by smaller businesses as well as by large industrial companies offers the only possibility for achieving the annual national gross product of $560 billion already forecast for 1966, according to R. V. Coles, general manager of Fielden Instrument Division of Robertshaw-Fulton Controls Co. The labor force, according to Coles, cannot expand by more than 14 per cent in the next ten years, and only through industrial mechanization and automation can every worker's productivity be increased by the 25% needed to meet the expected demand for goods in 1966. According to Coles, smaller manufacturers can justify automation in their operations by renting giant computers manned by experts at an economical figure, and much equipment is within their economic means. □

A new manufacturing plant and home office will be constructed at Fort Washington, Pa., by Minneapolis-Honeywell's Valve Division. □

Construction is underway on a nitric acid concentrator at the El Dorado chemical plant of Lion Oil Co., a division of Monsanto. The unit, which concentrates 58% nitric and is expected to produce 40 tons per day of 95% nitric, is being designed and built by Chemical and Industrial Construction Co., a subsidiary of Chemical and Industrial Corp., Cincinnati, O.

Housed in a steel framework four stories high, the new unit also includes blending facilities to produce 68% nitric. The nitric will be used primarily as raw material for another Monsanto plant. □

Du Pont is said to be studying the possibility of increasing its yearly production of methanol by some 30 million gallons. Increase would be at the company's Sabine River Works, Orange, Tex. □

A new antibiotic plant has been opened at Arnprior, Ontario, Canada, by Chas. Pfizer & Co., Inc. □

PROTOTYPE FERRO-MANGANESE PLANT

Now in operation at Niagara Falls, Ontario, is the $2-million prototype ferromanganese plant of Strategic-Udy Metallurgical and Chemical Processes, Ltd. The plant has been specially designed to test the operation of the new process and techniques pioneered by Marvin J. Udy, vice-president of the company, which is a subsidiary of Strategic Materials Corp.

Previously proven in pilot plant scale, the process and techniques now being used in the prototype plant are expected to yield complete design criteria for the proposed production plant at Woodstock, New Brunswick.

The smelting techniques employed by Udy's process in the highly automatized prototype plant represent a modification of conventional practices in both principles and equipment. They permit very close control of smelting temperatures combined with supervision of the chemistry of the reactions in the stages of the process.

Since the same smelting practices are followed in the company's processing of high-iron bauxite ores, ilmenite (titanium) ores, and other ores, the prototype plant has been designed with the degree of flexibility necessary to permit production testing of the other processes.

If actual design engineering works out on schedule, the main New Brunswick plant should go into construction in the spring of 1957.

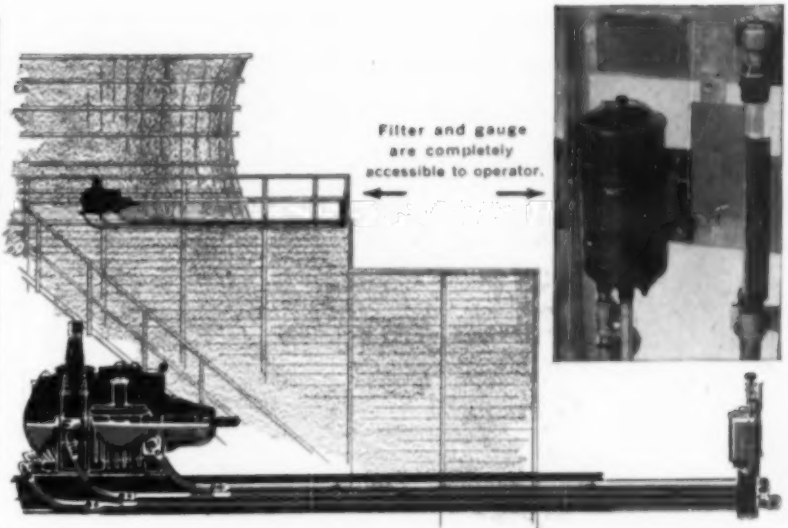
LARGE ETHYLENE PLANT PLANNED

Construction has already begun on a multi-million-dollar petrochemical plant at Lake Charles, La., to produce 200 million pounds of ethylene a year. Being built for Petroleum Chemicals, Inc. (jointly owned by Cities Service Co. and Continental Oil Co.) by the Lummus Co., the new plant will be one of the first to offer commercially both the standard and high-purity grades of ethylene.

Another indication of the rapid and firm growth of polyethylene plastics, anti-freezes such as ethylene glycol, and other ethylene-based products, the new plant is expected to be on-stream by January, 1958.

Refinery gases from the Conoco and Cities Service refineries at Lake Charles will be the raw material for producing the ethylene.

Petroleum Chemicals also expanded its adjacent butadiene plant recently, plans the construction of a 300-ton/day anhydrous ammonia plant at Lake Charles.



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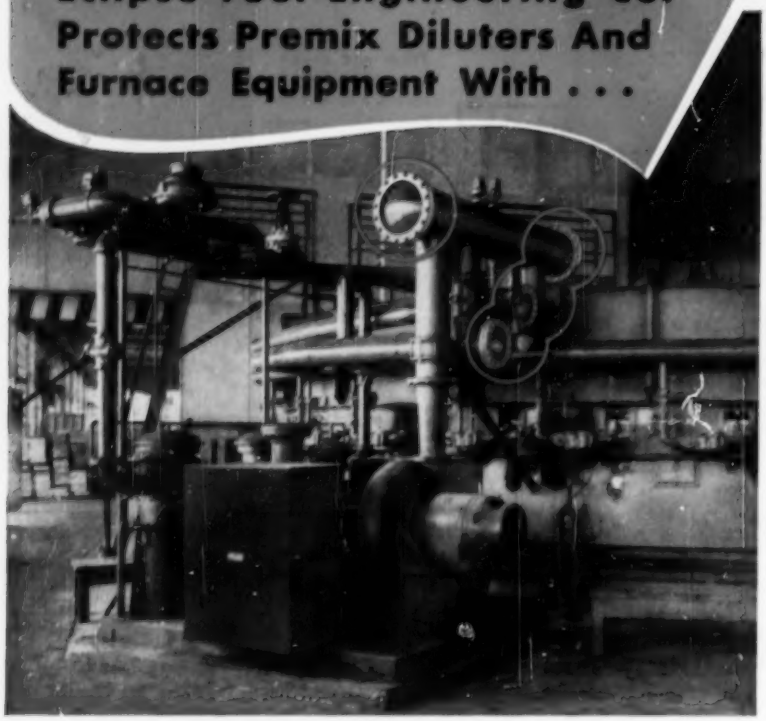

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BS&B — ANOTHER EXAMPLE OF PRODUCT LEADERSHIP

INDUSTRIAL NEWS

A "robot brain" which quickly solves many tough engineering problems has been installed by the Gas Process Division of The Girdler Co. and will be available to all the company's major technical groups. The "brain" is a Burroughs E 101, is about the size of an office desk, is a digital computer which automatically handles problems too small to be solved economically by the giant electronic computers and yet too complex to be worked out on a manual calculator without the investment of excessive man hours of the engineer's time. □

A $19 million Great Lakes area expansion program by National Gypsum Co., will involve the construction of two gypsum plants and the development of a 75 million ton northern Michigan gypsum deposit. □

Engineering, procurement and construction of a $2-million Houdriformer unit for Texas City Refining Co. will be done by Catalytic Construction Co. of Philadelphia. □

National Petro-Chemicals Corp. is now in full commercial production of medium-density polyethylenes. A high-pressure production technique will be used in Petro's existing polyethylene plant at Tuscola, Ill. Petro is a subsidiary of National Distillers and Panhandle Eastern Pipeline. □

Corrosive and noxious acid fumes from metal plating tanks can be smothered under a blanket of hollow spheres molded of polyethylene that resists almost indefinitely the acid solutions the spheres float on. Ordinarily, according to Bakelite Co., a division of Union Carbide & Carbon, and a leading producer of polyethylene, gas bubbles rise to the surface of metal plating solutions and burst, throwing a fine, corrosive mist into the air. To prevent this, Cosom Industries, Inc., Minneapolis, Minn., designed these hollow spheres of polyethylene to form an evenly spread blanket over the surface of the tank.

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Now you don't have to sacrifice instrument performance and readability to size considerations. With Republic's new line of small-size V5 Gauges, you can save panel space, make more compact instrument groupings and *still* get the accuracy, sensitivity and readability you would expect from conventional sized instruments. Full sized diaphragms, bellows and helix units in V5 Gauges assure "big" gauge performance in an instrument that requires only one-fourth the panel space of conventional gauges. Five inch scales are almost flat and are indirectly illuminated as a standard feature for easy reading — even from a distance.

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This seal is available from stock as optional equipment on all new pumps and can replace standard stuffing boxes on all existing Eco rotary pumps in the field.

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Our engineering advisory service is at your disposal. Write or phone Eco on your pump problems. We'll be pleased to make specific recommendations.

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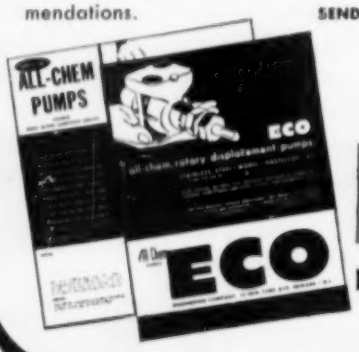

the big name in small pumps

ECO

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This air shipment of 1,000 pounds of pyrethrins, the active ingredient of pyrethrum flowers from Africa and a major insecticide base, highlights two major international chemical developments—the start of production in the Belgian Congo's first pyrethrum extraction plant at Bukavu, and the air-lift necessitated by the blocking of the Suez Canal. The 1,000 pounds shown arriving at New York's Idlewild Airport come from the Bukavu plant which can process as high as 2,700,000 pounds of flowers a year, will greatly reduce shipping costs to American users who heretofore have bought the unprocessed flowers.

Plans for the immediate construction of a multi-million-dollar plant to manufacture 100 million pounds of ethylene annually, utilizing refinery gas as its basic raw material, have been announced by Union Oil Co. The plant, to be located at Union's Los Angeles refinery, will be completed in 1958. A substantial portion of the ethylene will be pipelined to nearby Brea Chemicals-Koppers Co. joint polyethylene plant. The remainder will be available for purchase by other chemical manufacturers. □

Cuprous chloride is now being produced by the Henry Bower Mfg. Co. at Philadelphia, Pa. The product meets the rigid physical and chemical specifications for such uses as catalysts, phthalocyanine colors, and special batteries. □

The capacity of Stauffer Chemical's San Francisco boric acid plant will be increased by 50%. Expected to cost some $500,000, construction work is already underway on the additional capacity. □

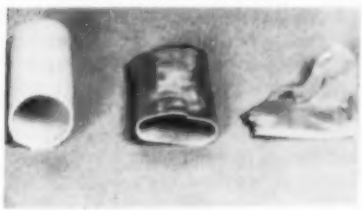
A new plant for the commercial production of styrene-butadiene latexes is now in operation at the Western Division of The Dow Chemical Co. in Pittsburg, Cal. □

GRACE ACQUIRES POLYETHYLENE IRRADIATION PROCESS

Hyrad Process, to which Grace now has U. S. and world rights, uses irradiation to improve and modify polyethylene and other polymers.

W. R. Grace recently announced the acquisition from the Sequoia Process Corp. of Redwood City, Calif., of exclusive rights to the Hyrad Process for the irradiation of polyethylene and other polymers.

Said T. T. Miller, president of Grace's Polymer Chemicals Division, "Grace's acquisition of the exclusive license under this new process implements our program now underway with the building of an $18,000,000 plant in Baton Rouge, Louisiana, for the manufacture of a new high-density polyethylene licensed by the Phillips Petroleum Company. The process will thus combine the advantages of high-density polyethylene, which in itself marks a great advance in polyethylene properties, with the benefits of irradiation."



A dramatic example of how plastic tubing made by the new process resists high temperatures. Three samples of polyethylene were exposed to 300° F. for 96 hours. On the right: an untreated sample. Center: simply irradiated. Left: modified by the new process and then irradiated.

Koppers Company expects to be the first in the country to produce expandable polystyrene in commercial quantities when its full-scale commercial plant goes on-stream at Kobuta, Pa., early in 1958. The expandable polystyrene has been produced in semi-commercial quantities at Kobuta since Koppers first announced its availability over two years ago, and some of the existing facilities will be utilized in the full-scale plant. Currently Koppers is expanding its semi-commercial production to take care of immediate customer needs. □

100 plus octane (with TEL) will be produced by the New Standard Oil Co. (Indiana) Ultraforming process at its Neodesha, Kansas, refinery. Foster Wheeler Corp. will construct the unit. □

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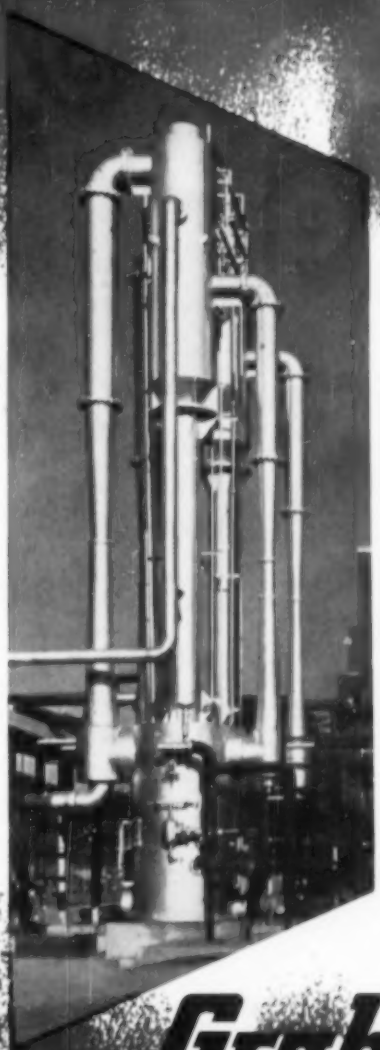
(Graham Steam Vacuum Refrigeration)



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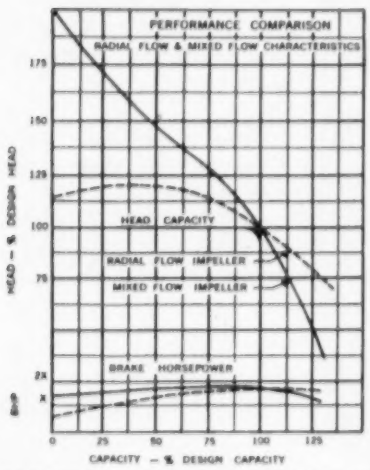

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Sodium chlorate production will be expanded by some 5,000 tons per year at The Oldbury Division, Hooker Electrochemical Co., plant at Columbus, Miss. The enlarged plant will be completed in early 1958, will raise total annual capacity to 22,000 tons.

A major expansion of Jefferson Chemical Co.'s petrochemical plant at Port Neches, Tex., is now underway, will:

1) Triple production facilities for ethylene.

2) Double capacity for ethylene glycol.

3) Increase by 50% the production of ethylene oxide.

The program will include installation of a direct oxidation unit, although the company will continue operation of its existing chlorohydrination equipment, will produce ethylene oxide by both processes.

Jefferson will also construct a chlorine plant for producing ethylene oxide and ethylene dichloride. Much of the caustic soda from this plant will be marketed, while the hydrogen will be used by Jefferson.

The new facilities also mark Jefferson's entry into the production of propylene oxide, glycol and other propylene derivatives. □

Polymer Engineering and Development Corp., Newark, N. J., has been organized for the purpose of offering the complete service of pilot plant facilities, process development, engineering design and construction of resin and polymer plants. Services will also include plant design and layout for resin and plastic fabrication. The new company is an adjunct to Resin Research Laboratories, Inc., also of Newark. □

General contractor for the new $6.5 million tantalum-columbium plant of Fansteel Metallurgical Corp. at Muskogee, Okla., will be the Dickmann-Pickens-Bond Construction Co. of Muskogee. The plant will produce tantalum and columbium metal powder and ingots, will double tantalum capacity of the company and increase columbium capacity 150%. □

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FIRST-OF-ITS-TYPE PHTHALIC ANHYDRIDE PLANT IN PLANNING STAGE

Amoco Chemical Corp., now being formed from various chemical subsidiaries of Standard Oil Co. (Indiana), plans $10 million installation in mid-west.

Exact site of Amoco's new phthalic anhydride plant has not been determined. But it will be in the mid-west, construction is scheduled to begin early in 1957 and be completed in 1958.

The plant will be operated on a hydrocarbon oxidation process on which Standard now has world-wide rights, and will be the first phthalic plant to use the process here.

The process is a liquid phase oxidation with air of various substituted aromatic hydrocarbons for their conversion into the corresponding aromatic acids. It will be designed to convert a number of aromatic raw materials to produce a variety of products other than phthalic, including terphthalic acid used to make polyesters such as Dacron.

The process is considered unique in the field because it will produce a diversified line of chemical products in a single installation (such as Amoco's) from one source of raw materials.

An $8 million plant to produce magnesia and basic refractory products will be built by H. K. Porter in Pascagoula, Miss. Completion is scheduled for early 1958. □

The new Brunswick, Ga., chlorine-caustic soda plant of Solvay Process Division (Allied) has now completed preliminary testing of equipment, is in full commercial production. The new installation is the first step in Solvay's two part construction program at Brunswick. □

Construction has begun on a new foot valve parts plant for Valve Products, Inc., subsidiary of Rockwell Mfg. Co. It will produce parts for Rockwell-Edward high-pressure, high-temperature valves, and Rockwell-Nordstrom lubricated plug valves. The valves are used throughout the chemical, petroleum and gas, and most other technological industries. □

Production capacity of Chemstrand Corp.'s Pensacola, Fla., nylon plant will be increased again, this time to 114 million pounds per year. □

This new plant under construction for Superior Tube Co. in Wapakoneta, Ohio, will more than triple the floor space of the company's present leased facilities, will boost production of small tubing and electronic parts by 30%. In the new building the company expects to increase the size limits of its tubing from 3/16" to 3/8" outside diameter, eventually expects to go to 1/2 inch outside diameter.

The new electric furnace plant of the Norton Co. at Huntsville, Ala., will manufacture a variety of materials including boron carbide, fused zirconia, fused magnesium oxide, and fused alumina. At a later date the company expects to add facilities for making aluminum oxide and silicon carbide. □

Engineering work on a hydrogen plant for Metal Hydrides' new facility at Danvers, Mass., will be done by The Girdler Co., a division of National Cylinder Gas Co. The hydrogen plant will employ propane as feed stock and produce hydrogen of 99.8% purity. Girdler catalysts will be used in the processing operation. □

An $8 million plant for the production of 60 million pounds per year of ethylene oxide and 35 million pounds per year of ethylene glycol will be constructed for General Aniline by SD Plants, Inc., N. Y. Design and engineering is being done by SD Plant's parent, the Scientific Design Co. of New York. SD's direct air oxidation process will be used. □

Large scale production of Niacin U.S.P. is now underway at Cowles Chemical Co., Cleveland, O. Cowles is producing Niacin by a unique catalytic air oxidation process which is the result of two years' research work at the company labs. □

Engineering, procurement and construction of an 80,000 bbl./day vacuum pipe still at the Texas Co.'s Port Arthur, Tex., refinery, will be done by the Fluor Corp. Ltd. The new still will replace existing units and will result in a 20,000 bbl./day increase in the crude capacity of the refinery.

Construction will begin in February, 1957, completion is expected in December, 1957. □

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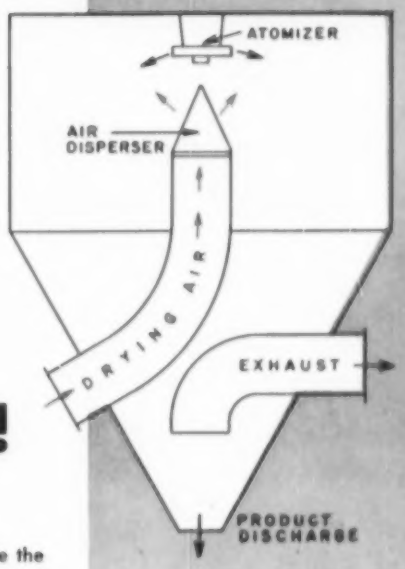

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CHEMICAL CONTRACT
The Fluor Corporation, Ltd., Los Angeles engineering
and construction firm, has been awarded a contract by
Wyandotte Chemicals Corporation to design, engineer
and construct a large capacity electrolytic chlorine-caus-
tic soda manufacturing plant at Wyandotte's new plant
site near Baton Rouge, La.
This 1200-acre site on the Mississippi River, where an
$8,000,000 ethylene oxide plant is already under construc-
tion, has been named the Geismar Works. The new elec-
trolytic plant will require an investment of over $20,-
000,000 and construction will begin in mid-1957, with
completion scheduled for the last half of 1958. The
Geismar facilities will increase by nearly 60% the total
caustic soda and chlorine capacity of Wyandotte
chemicals.
major projects under construction by Fluor in
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16	17	18	19	20	21	22	23	24	25	26	27	28	29
30	31	32	33	34	35	36	37	38	39	40	41	42	43
44	45	46	47	48	49	50	51	52	53	54	55	56	57
58	59	60	61	62	63	64	65	66	67	68	69	70	71
72	73	74	75	76	77	78	79	80	81	82	83	84	85
86	87	88	89	90	91	92	93	94	95	96	97	98	99
100	101	102	103	104	105	106	107	108	109	110	111	112	114
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31A 32L 33A 34A 35A 37A 39A 40L 41A 42A 43A
44L 45A 46A 47A 48A 50A 2-J 51A 55R 56L 57A
58L 59R 60L 61A 62L 63R 64A 69A 71A 73A 75A
77R 78L 79R 80TL 80BL 81A 82A 86L 87A 88L 89A
91A 92L 93A 95A 96L 97A 98L 99A 100TL 100BL 101R
103A 104L 105TL 105BL 105R 106L 106R 107R 108L 109A 110L
110R 111TR 111BR 112L 112BR 113R 114TL 114BL 115R 118L
119R 120L 121R 121L 122L 123A 124L 124R 125R 126L 127R
128L 129R 130L 131TL 131BL 131R 142TL 142BL 142BR 143BL
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Chemical Engineering Progress Data Service

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Position .....

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City ..... Zone ..... State .....

☐ I want a subscription to C.E.P. Bill me $6.00 for a year.
☐ Send information on Philadelphia Nuclear Congress.
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January, 1957

Please do not use this card after April, 1957

1	2	3	4	5	6	7	8	9	10	11	12	14	15
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58	59	60	61	62	63	64	65	66	67	68	69	70	71
72	73	74	75	76	77	78	79	80	81	82	83	84	85
86	87	88	89	90	91	92	93	94	95	96	97	98	99
100	101	102	103	104	105	106	107	108	109	110	111	112	114
115	116	117	118	119	120	121	122	123	124	125	126	127	128
129	130	131	132	133	134	135	136	137	138	139	140	141	142

Advertisers' Products

IFC 3R 4A 6A 7A 9A 10L 11A 12A 13A 14L
15A 16A 18L 19A 20A 21A 23A 24A 27A 28A 30A
31A 32L 33A 34A 35A 37A 39A 40L 41A 42A 43A
44L 45A 46A 47A 48A 50A 2-J 51A 55R 56L 57A
58L 59R 60L 61A 62L 63R 64A 69A 71A 73A 75A
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91A 92L 93A 95A 96L 97A 98L 99A 100TL 100BL 101R
103A 104L 105TL 105BL 105R 106L 106R 107R 108L 109A 110L
110R 111TR 111BR 112L 112BR 113R 114TL 114BL 115R 118L
119R 120L 121R 121L 122L 123A 124L 124R 125R 126L 127R
128L 129R 130L 131TL 131BL 131R 142TL 142BL 142BR 143BL
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☐ Send information on White Sulphur Meeting.

January, 1957

the chemical engineers'

DATA SERVICE

and

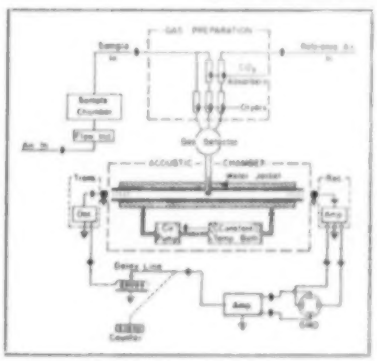
GUIDE

to significant developments in

- **EQUIPMENT**
- **MATERIALS**
- **SERVICES**

developments of the month–

SONIC GAS ANALYZER



87 National Instrument Laboratories, Inc., has just released a gas analyzer employing the velocity of sound & said to offer exceptional range, sensitivity & rapidity of analysis.

Developed by Merck & Co., the Sonic Gas Analyzer exploits the wide differences in sonic velocity by achieving such measurable sensitivities as 0.005 per cent of oxygen in air & 0.00061 per cent of hydrogen. The high sensitivity remains the same over the range of 0 to 100 per cent.

The instrument contains a long tube in which the velocity of the sound is measured. The gas is fed into the sonic tube at its center & flows out at both ends, so that the velocity of flow does not increase or decrease the rate of sound transmission. Sound waves are generated at one end of the tube & are received by a crystal transducer at the other end. An oscillation frequency of approximately 150 kc per second is used to give high sensitivity. The phase of the received signal is compared with that of the generating crystal & the phase shift is a precise measure of the change in velocity of sound propagation. Circle No. 87 on Data Post Card.

(Continued on page 66)

TURN THIS PAGE TO RIGHT FOR MORE . . . .

HOW TO USE THIS POST CARD FOLDER

Merely encircle numbers on cards to get literature desired. On advertised products in front of magazine, fold this page out to right. For those in back, fold card strip again to right, where card strip is scored for detaching.

products-

advertised in this issue

IFC Carbide & Carbon Chemicals. Booklet with latest physical properties & condensed application data for more than 335 organic chemicals. Carbide & Carbon Chemicals Co.

3R Rotary Sifter Data. The Bar-Nun Rotary Sifter provides up to 40 sq. ft. screen surface in 3½ sq.ft. floor area. Details & recommendations. B. F. Gump Co.

4A Demisters. Bulletin gives details of construction & performance of Yorkmesh Demisters. Case history list also available. Otto H. York, Inc.

6A Engineering Design & Procurement. Ralph M. Parsons Co. builds new plant for Callery Chemical Co. for producing high-energy fuels.

7A Controlled-Volume Chemical Pumps. Lapp Insulator Co. offers bulletin with typical applications, flow charts, description & specifications of Lapp Pulsafeeder controlled-volume pumps.

9A Mercury Arc Rectifiers. Complete technical information on Allis-Chalmers mercury arc rectifiers.

10L Chemiseal Expansion Joints & Flexible Couplings. Made of teflon, protect costly chemical piping. Bulletin from United States Gasket Co.

11A SK Fume Scrubbers. Many applications in the chemical processing, food, & petroleum industries. Schutte & Koerting Co.

12A Valve Case Histories. Book with 32 case histories of Crane valves throughout industry. Crane Co.

13A Engineering & Design Services. Sulfuric acid plant, built by the Lummus Co. in Alberta, Canada, completed ahead of schedule.

14L Centrifugal Pump Data. Catalog gives complete specifications on all Eastern centrifugal pumps. Eastern Industries, Inc.

15A Ion-Exchange Systems. Complete ion-exchange systems for water-conditioning, chemical processing, industrial waste treatment. The Permutit Co.

16A-17A Pneumatic Control Valves. From high vacuum work to operation at 30,000 lb./sq.in. & for temperatures from —350 to +1,000° F. Details from the Foxboro Co.

18L Wire Cloth Catalog. Newark Wire Cloth is made in all malleable as well as noble metals. Large stock, prompt shipment. Newark Wire Cloth Co.

19A Corrosion-Proof Equipment. "Karbate" heat exchangers, pumps, & armored piping of impervious graphite give extra safety with corrosives. National Carbon Co. Bulletins.

20A Equipment Fabrication. Koven Fabricators, Inc. are specialists in intricate fabrication in a wide variety of metals & alloys. Consulting services.

21A Pressure Filters. The Eimco Corp. has complete facilities to test your slurry on all types of filtration equipment.

23A Vinyl Resins. Complete line of vinyls engineered to your specific needs. Details from Chemical Sales Division, Firestone Plastics Co.

24A-25A Filter Aids. Celite assures superior clarification at fast flow rates plus lower wet density. Consulting services. Johns-Manville.

27A Non-Lubricated Compressor Cylinders. NL construction is the answer to many compressor problems where oil may not be used. Ingersoll-Rand.

28A-29A Computers in Engineering Design. Large digital computer now enables M. W. Kellogg Co. engineers to produce results with unprecedented thoroughness, accuracy & speed.

30A Chemical Porcelain Products. Wide variety of valve styles, pipe & fittings, towers & Raschig rings & many special shapes available. Bulletin from Lapp Insulator Co., Inc.

31A Super Classifier. The Sharples Super Classifier provides ultra-sharp separations at high capacity. The Sharples Corp.

32L Corrosion Resistant Vaporizers. In stainless steel 317L, high chrome stainless steel 430, Inconel, 3½% nickel steel. Richard M. Armstrong Co. Consulting services.

33A Steam Tube Dryers. General American Transportation Corp. offers data on advantages of steam tube dryers. Routine pilot-plant tests without charge.

34A Hydrogen Plant Design & Construction. More than 45 Girdler hydrogen plants giving outstanding performance in U. S. & Canada.

35A-36A Zirconium & Titanium Corrosion Data. U. S. Industrial Chemicals offer tabular data & literature references.

37A Turbine Type Flow Meters. Potter Flowmeters available from ⅛-in. to 6-in. units for temperatures up to 1,200° F. & pressures to 35,000 lb./sq.in. Bulletin from Potter Aeronautical Co.

39A Industrial Blowers. Roots-Connersville Blower offers experienced engineering service for any product or process application.

40L High-Pressure Needle Valves. Bulletin from August Spindler & Sons, Inc. gives technical data on big & small high-pressure needle valves for refineries & chemical plants.

41A International Atomic Exposition. To be held in Philadelphia March 11-15, 1957. Registration information from Engineers Joint Council, 29 West 39th St., New York 18, N. Y.

42A Technical Booklet on Catalysts. Describes granular, pelleted, powdered, spherical, extruded catalysts. Also supports & active agents. Davison Chemical Co.

43A Sealless Pumps. Vanton sealless pumps have no stuffing box or mechanical seal. Self-priming, high vacuum. Vanton Pump & Equipment Corp.

44L Spiral Ribbon Mixers. For granular or pulverized, wet or dry materials. Complete details from Read Standard Corp.

45A Engineering & Construction Services. Badger Manufacturing Co. designs & builds new ultra-fractionation & styrene manufacturing plant for Cosden Petroleum.

46A Process Flowmeters. Bulletins & selection guides for all types of chemical process flowmeters. Fischer & Porter Co.

47A Automatic Filters. Bulletin from R. P. Adams Co. describes advantages of backwash design used in Adams AWF automatic filters.

48A Non-Pressurized Liquid-Phase Heating Systems. Arochlor 1248 makes possible heating systems operating at atmospheric pressure up to 600° F. Technical information available from Monsanto Chemical Co.

50A Laboratory Compressors. For compressing gases to 5,000 atmospheres in laboratories & pilot plants. Catalog from Autoclave Engineers.

Developments of the Month

(Continued)

88 Submersible Pump. Neptune Pump Manufacturing Co. announces a new, improved submersible pump for the disposal of various chemicals from containers or wherever transfers of liquids are necessary.

The pump is constructed entirely of 304 & 316 stainless steel. It measures 12 inches in diameter & is 14 inches high. It is portable, weighing only 35 pounds. The pump has a 1¼ inch discharge, a capacity of over 3,000 gal./hr., and heads up to 21 TDH. It is powered by a 1/3 hp. motor. Circle No. 88 on Data Post Card.

(Continued on page 67)

DEVELOPMENTS OF THE MONTH *(Continued)*

2-J Pulverizing, Air Conveying, Dust Collection. Consulting services on problems involving spray or dust collection, pulverizing or conveying of finely-divided materials. Metals Disintegrating Co., Inc.

51A Plastic Tubing Manual. Gives physical, chemical characteristics, working pressures & temperatures of Tygon plastic tubing. U. S. Stoneware.

53R Engineered Lubrication for Cooling Towers. Marley Packaged Tower Power is the only tower mechanical equipment with "engineered lubrication." Details from the Marley Co.

56L Safety Heads. B.S.&B. safety heads protect pressurized equipment from damage wherever overpressure may occur. Black, Sivalls & Bryson.

57A Small-size Gauges & Receivers. Bulletin from Republic Flow Meters Co. gives technical details of new line of small-size gauges & receivers.

58L Corrosion-resistant Rotary Pumps. New Eco rotary pump uses a fluid teflon dispersion as a hydraulic sealing medium. Eco Engineering Co.

59R Low Cost Cold Water. Graham steam vacuum refrigeration system for cheap refrigeration. Graham Manufacturing Co., Inc.

60L Vertical Close-Coupled Pumps. Verti-Line pumps, product of Layne & Bowler Pump Co., offer capacities from 20 gal./min. to 30,000 gal./min., heads to 600 lb./sq.in. Bulletin.

61A Vinyl Frame Safety Goggles. More comfort, full ventilation, complete all-around protection. Watchemoket Optical Co.

62L Oil Reclaimer Systems. Hilco oil reclaimer systems provide higher vacuum, lower pump maintenance costs. Bulletin from the Hilliard Corp.

63R Spray Dryers. Nerco-Niro spray dryers offer safe & economical method of drying heat-sensitive materials, both organic & inorganic. Nichols Engineering & Research Corp.

64A Engineering & Construction Services. All types of plants for the petroleum, chemical, & power industries. Fluor Corp.

(Continued on page 68)

89 Corrosion-resistant Impeller. The Pox-Y-Lite impeller has been in use in extrusion machines at 450° F. for as long as 2 years with no sign of deterioration, in the recovery of fumes given off during the extrusion of acetate, viscose & similar products, & returning them for reuse. Pox-Y-Lite is an epoxy resin compound manufactured by the Homalite Corp. These impellers are said to have superior resistance to organic acids, dilute mineral acids, caustics, alkalines & most solvents & to have the highest tensile, impact & flexural strength of all the cast resins. Homalite will supply either cast impellers or other products in Pox-Y-Lite to your designs or supply raw materials for castings by other manufacturers.

(Cont. on page 68)

Numbers without letters indicate data available as described in Data Service "Briefs." Numbers with letters refer to further data concerning products advertised in this issue. Letters indicate position of advertisement on page (if more than one on a page)—L, left; R, right; T, top; B, bottom; A indicates full page; IFC, IBC, and OBC are cover advertisements.

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First Class Permit No. 48890, Sec. 34.9, P. L. & R., New York, N. Y.

CHEMICAL ENGINEERING PROGRESS
25 West 45th Street
New York 36,
New York

No Postage Stamp Necessary If Mailed in the United States

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CHEMICAL ENGINEERING PROGRESS
25 West 45th Street
New York 36,
New York

No Postage Stamp Necessary If Mailed in the United States

products-

advertised in this issue *(Cont.)*

69A Laboratory Spray Dryer. Interchangeable nozzle or wheel atomization provides extreme operating flexibility in the Bowen conical laboratory spray dryer. Bowen Engineering, Inc.

71A Low Nickel Stainless Steels. Rezistal 201 & 202, new grades offered by Crucible Steel Co. of America, have interesting new properties. Data sheets.

73A "Packaged" Mixers. Designed for maximum adaptability to all fluid agitation applications. Philadelphia Gear Works, Inc.

75A Valves. Bulletin from the Duriron Co. describes technical details of Durco Type F valves.

77R Fluid Flow Meters. Gentile Flow Tubes are designed for high accuracy with lowest head loss. Information & recommendations from Foster Engineering Co.

78L Heat Exchanger Design Data. Useful bulletin offered by Downingtown Iron Works, Inc.

79R Chilled Water Systems. "Chill-Vactor" systems, built by Croll-Reynolds Co., can use excess steam capacity for economical water chilling. Literature.

80TL High-Purity Fused Quartz. Standard apparatus, crucibles, trays, cylindrical containers, etc., available for early delivery. Amersil Co.

80BL Teflon Packing. Dura Plastic teflon packing, in die-molded ring or spiral form for corrosive service. Bulletin from Durametallic Corp.

82L Construction Services. Graver Construction Co. are plant builders for the chemical processing, nucleonics, oil refining, petrochemical, power, & steel industries.

86L Rota-Cone Vacuum Dryer. Paul O. Abbe, Inc. offers folder containing specifications on new Rota-Cone vacuum dryer.

87A Shell & Tube Heat Exchangers. Ross Heat Exchanger Division of American-Standard offers long experience in the specially-engineered shell & tube heat exchanger field. Consulting services.

88L Vertical Jacketed Pumps. Lawrence vertical jacketed pumps are designed for liquids which tend to solidify or become viscous at low temperatures. Lawrence Pumps, Inc.

89A Tubular Products. Seamless & welded tubular products, fittings & forged steel flanges in carbon, alloy, & stainless steels. Babcock & Wilcox Co.

91A Condensed Pump Catalog. Complete catalog of line of Aldrich Pumps. Also data sheet. Aldrich Pump Co.

92L Mix-Mullers. New bulletin "Mulling for the Chemical Industries" offered by National Engineering Co.

93A Polyethylene Tower Packing. Folder describes increased efficiency & capacity, lighter weight, tray column characteristics of Tellerette. Harshaw Chemical Co.

95A Stainless Steel Fabrication. Stainless steel plate, forgings, bars, & sheets. G. O. Carlson, Inc.

96L Filter Press Guide. T. Shriver & Co. offers booklet entitled "Shriver Guide to Better Filtration."

97A Chemical Process Catalysts. The Girdler Co. offers a variety of important catalyst services, including proper application of catalysts to your specific problem.

98L Spray Nozzles. Spray Engineering Co. offers complete line of full-cone spray nozzles. Literature.

99A Process Equipment. Pfaudler Co. will send data sheets and bulletins on wiped-film evaporators, dryer-blenders, glassed-steel reactors.

100TL Vibra Screw Solids Feeder. New feeder, made by Vibra Screw, said to meter solids like liquids. Bulletins.

100BL Equipment Design & Fabrication. All types of chemical process equipment including pilot plants & complete plants. Information available. Artisan Metal Products, Inc.

101R Stainless Steel Heat Exchangers. Standardizers to insure lower prices & quick delivery. Doyle & Roth Manufacturing Co.

103A Bulk Material Conveying Systems. Stephens-Adamson Manufacturing Co. offers expert consulting services on your conveying needs.

104L Glass Laboratory Equipment. Complete stock ready for immediate shipment. Ace Glass, Inc.

105TL Spray Nozzle Catalog. 48 pages of information on thousands of nozzle types & capacities. Spraying Systems Co.

105BL Rotameter Bulletin. Describes data application, construction, materials available, installation, & operation of "Safeguard" Rotameters. Schutte & Koerting Co.

105R Teflon Products. Price list & sizes of teflon spaghetti & flexible thin wall tubing. Reports on custom-molded teflon. Sparta Manufacturing Co.

106L Fused Silica Lab Ware. Illustrated bulletin on unusually large stock of items. Thermal American Fused Quartz Co.

106R Protecting Tubes. Claud S. Gordon Co. offers bulletin with application data, specifications, on Serv-Rite protecting tubes & wells.

107R Indirect-Fired Dryers & Heaters. Bulletin with complete specifications of Ruggles-Cole dryers & heaters. Hardinge Co.

108L Impervious Graphite Heat Exchangers. Catalog from Falls Industries, Inc.

109A Horizontal Plate Filter. Cake maintains original position regardless of pressure fluctuation, flow rate, or viscosity. Sparkler Manufacturing Co.

110L Wood Processing & Storage Equipment. Engineering & construction of all types of wood equipment. Wendnagel & Co.

110R Water Treatment Systems. Consulting service on ion-exchange water treatment systems offered by Illinois Water Treatment Co.

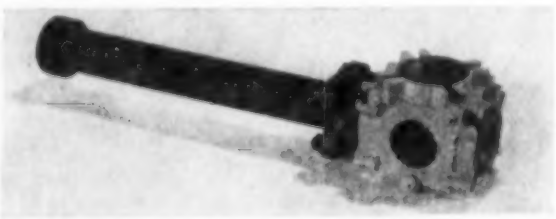
111TR Protection against Skin Irritants. "Kerodex" gives protection from epoxy resins, amine hardeners, solvents, cutting oils, etc. Ayerst Laboratories.

111BR Remote-control Valve Operator. The Babbitt adjustable sprocket rim with chain guide allows reaching all overhead valves without danger. Babbitt Steam Specialty Co.

112L Filter Press Catalog. Complete with illustrations & specifications for planning new filtration facilitites. D. R. Sperry & Co.

(Continued on page 70)

DEVELOPMENTS OF THE MONTH *(Continued)*



90 Armored Graphite Pipe & Fittings. "Karbate" brand impervious carbon & graphite pipe & fittings, made by National Carbon Co., are now available with an external armoring to protect against accidental breakage.

A strong glass fabric bonded to the carbon pipe not only armors & strengthens the pipe but, in case of breakage, it remains intact, holding line pressure & preventing gross leakage. Connections to the graphite fittings are made through a protective metal housing which isolates the fitting from external mechanical stresses caused by misalignment or piping expansion or contraction.

"Karbate" armored pipe is available in one- to four-inch diameters in lengths up to nine feet, with either flanged or plain ends. Armored fittings, in one- to four-inch pipe sizes, are available as 90-degree elbows, tees, couplings, & flange collars. Circle No. 90 on Data Post Card.

(Continued on page 70)

NEW!

BOWEN CONICAL LABORATORY SPRAY DRYER

Interchangeable Nozzle or Wheel Atomization provides extreme operating flexibility

CAPACITY
15 to 80 lbs/hr water evaporation depending on inlet temperature and product drying rate

The New Bowen Conical Laboratory Spray Dryer has been especially designed for economical product evaluation and production of limited quantities of valuable materials. Particular attention has been given to operating features and ease of cleaning. Surfaces in contact with feed material and product are stainless steel throughout. Drying temperatures are variable up to 1000°F to accomodate a wide variety of materials.

The New unit can be seen in operation, by appointment, at the Bowen Laboratory in North Branch.

Write for Bulletin 34

Describes the Bowen Conical Laboratory Spray Dryer in detail and gives complete technical specifications.

BOWEN ENGINEERING, INC.
NORTH BRANCH 13, NEW JERSEY

Recognized Leader in Spray Dryer Engineering Since 1926

BOWEN SPRAY DRYERS
Always Offer You More!

products-

advertised in this issue *(Cont.)*

112BR Stainless Steel Tanks-Agitators. Literature from Arthur Colton Co.

113R Furnace Castings. Metallurgical consulting services on casting problems offered by the Duraloy Co.

114TL Laboratory Glassware. The Diamond D Blue Line assures built-in accuracy & uniformity. Doerr Glass Co.

114BL Bulk Material Control Equipment. The new Roto-Bin-Dicator operates under either pressure or vacuum. Bin-Dicator Co.

115R Equipment Fabrication. Design & fabrication of units to fit your particular process need, priced to fit your budget. Manning & Lewis Engineering Co.

118L Rotary Joints. Barco Type C rotary joint is applicable to steam, water, oil, air or gas service. Catalog from Barco Manufacturing Co.

119R Self-cleaning Filter. Hydra-Shoe self-cleaning filter creates own air pressure for fast self-cleaning in seconds. Industrial Filter & Pump Mfg. Co.

120L Booklet on Tantalum. Data on uses of tantalum in the chemical process industries. Fansteel Metallurgical Corp.

121R Industrial Wire Cloth. Supplied in 9 weaves in any metal or alloy, bulk or fabricated parts. 80-page catalog. Cambridge Wire Cloth Co.

121L Design & Fabrication Services. Processing equipment designed, developed, manufactured. Catalog. Goslin-Birmingham Manufacturing Company, Inc.

122L Mixer Catalog. Alsop Engineering Corp. offers catalog on complete line of portable mixers.

123A Leak-proof Centrifugal Pumps. Pump & motor in single hermetically-sealed unit. Bulletin with complete details. Chempump Corp.

124L Air Scrubbers. Schneible Multi-Wash Collectors may offer the solution to your air scrubbing problem. Literature from Claude B. Schneible Co.

124R Centrifugal Pumps. Bulletin from Frederick Iron & Steel, Inc. on line of Frederick SSV pumps, enclosed & open impeller types.

125R Aero Heat Exchanger. Niagara Aero Heat Exchanger cools liquids & gases by evaporative cooling with atmospheric air. Bulletin from Niagara Blower Co.

126L Pulse Code Telemetering. Bulletin with full details on "Varec" pulse code telemetering. The Vapor Recovery Systems Co

127R Water Purification Equipment. Barnstead engineering & equipment has the answer to any water purification problem. Barnstead Still & Demineralizer Co.

128L Slime Control Systems. Bulletin from Wallace & Tiernan, Inc.

129R Tray Dryers. Specially-designed for wet, powdered, sensitive or unstable materials that must be dried slowly & with care. C. G. Sargent's Sons Corp.

130L Silicone Defoamer. Dow Corning Corp. will send free sample of "Antifoam B."

131TL Precision-Bore Tubing. Detailed catalog available from Wilmad Glass Co.

131R Flow Rate Regulators. Kates Direct-Acting Flow Rate Regulators require no outside connections except inlet/outlet piping. Technical bulletin from W. A. Kates Co.

142TL Vacuum Equipment. Steam jet ejectors, condensers, vacuum equipment. Jet-Vac Corp.

142BL Mixers. Precision-built batch mixers in capacities from 100 lbs. to 8,000 lbs. Literature from H. C. Davis Sons.

142BR Automatic Weighers. Single weighing units & fully programmed installations. Glengarry Processes, Inc.

143BL Technical Data Books. Pocket-size, loose-leaf. Free catalog. Lefax Publishers.

IBC Controlled Volume Pumps. Application data on controlled volume pumps in process instrumentation. Bulletin from Milton Roy Co.

OBC Process Mixers. Research Dept. of the Mixing Equipment Co. will cooperate with you in any experimental work on fluid mixing.

O **CIRCLE** *your Data Service requests on the handy postcard on page 65 to*

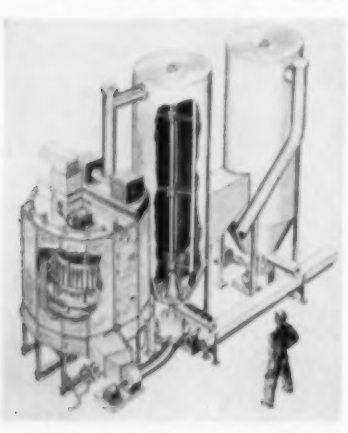
▶ **GET** *up-to-the-minute catalogs, data sheets and bulletins on new chemical products, processes and equipment.*

Technical Literature •

DEVELOPMENTS OF THE MONTH *(Continued)*

91 Closed Circuit Subliming System. A continuous, automatic, closed circuit system for the purification of certain solids by entrainer sublimation is offered by Wyssmont Company, Inc. The system operates at atmospheric pressure which permits continuous operation for several months without shut-down.

The assembly consists of the Wyssmont Turbo-Dryer Sublimer, feed hopper, recirculating fans, condensers & reheaters. In the sublimer there is a tier of tray shelves & turbo fans rotating on the same vertical axis within a cylindrical insulated housing.



The system is recommended for applications where:

1. Vaporization must be effected below the melting point.

2. A small percentage of the volatilizable product is mixed with a large percentage of non-volatile impurities & the finished solid product of high purity must be obtained in a single operation.

3. A pure finished solid product must be recovered from wet crude material in a single operation.

4. A mixture of volatile materials is to be separated & preferential condensation by control of condenser temperature & entrainer gas ratio make sublimation practical.

Wyssmont Turbo-Sublimers are built as completely shop-assembled units in sizes from 60 to 360 sq. ft. net tray areas. Larger units to 18,000 sq. ft. are sub-assembled for field erection. Circle No. 91 on Data Post Card.

(Continued on page 72)

equipment-

1 Flareless Tube Fitting. Hi-Seal, new type of flareless tube fitting introduced by Imperial Brass Mfg. Co. makes foolproof, butt-tight joint under full range of pressure conditions.

2 Turbidity Monitor Data Sheet. Specifications and applications of the recently-developed Turbistat which gives continuous monitoring of turbidity in fluids. Kaye Development Co. (Baird Associates-Atomic Instrument Co.)

3 Controlled Volume Pump. Bulletin from Milton Roy Co. describes and illustrates new line of sanitary liquid end controlled volume pumps.

4 Centrifugal Pumps. Four bulletins available covering details of wide range of centrifugal pump types. Kingsford Foundry & Machine Works.

5 Ductile Iron Fittings. Catalog from The Kuhns Brothers Co. describes line of cast iron pipe fittings including "K" pipe lock couplings, screwed and flanged fittings, and companion flanges.

(Continued on page 72)

now, Crucible low nickel stainless steels that meet many of your needs . . .

Here are two *new* Crucible grades, Rezistal type 201 and 202 that are similar in quality and properties to types 301 and 302 . . . but with desirable features all their own.

In the annealed condition, for example, Rezistal 201 and 202 have about 10% higher strength than 301 and 302, yet maintain almost identical ductility. This means that these grades can be fabricated with ease equal to their counterparts. In addition, their mill finishes and corrosion resistance to a wide variation of media compare most favorably with 301 and 302.

To sum up: Rezistal 201 and 202 have practically all the desirable properties of 301 and 302, *plus* some of their own. And they're available *promptly* in all forms. Write now for data sheets fully covering the properties of these new stainless grades. *Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa. Dept. AEP*

CRUCIBLE first name in special purpose steels

Crucible Steel Company of America

Canadian Distributor—Railway & Power Engineering Corp., Ltd.

equipment- *(Cont.)*

6 Non-rising Stem Gate Valve. 125 lb., S.W.P.; 200 lb., W.O.G. Non-shock type with solid wedge disc and brass construction. Details available from Milwaukee Valve Co.

7 Gyro-Shaker. Ideal for applications where all points of the screen must be readily accessible for rapid cleaning. Sprout, Waldron & Co.

8 Electronic Infra-red Analyzer. M-S-A Lira infra-red gas and liquid analyzers assure selective sensitive high-speed analysis of complex process streams. Mine Safety Appliances Co.

9 Caustic Recovery Evaporators. Illustrated booklet gives information on design, application, operation and construction of evaporators for the recovery of mercerizing caustic. Swenson Evaporator Co.

10 Flexible Couplings Catalog. Morflex torsionally flexible couplings described in 24-page catalog from Morse Chain Co. Complete dimensions, specifications and torsional deflection charts.

11 Miniature Shielded Thermocouples. Thermo Electric Co. offer bulletin including calibrations, temperature ranges, materials of construction, and immersion lengths.

12 Chromatographic Apparatus. The Chromacon, made by Podbielniak, Inc. is designed for continuous analysis of gaseous or liquid process streams. Illustrated bulletin.

14 Proportioning Pump Bulletin. Photos, capacity charts and dimensional drawings on new line of proportioning pumps. Proportioneers, Inc.

15 Fluid Transfer Systems. A new system of flexible hose links combined with quick-connect "snap-on" hose couplings manufactured by Titeflex, Inc. offers process economies. Literature.

16 Electric Motor Catalog. New 20-page catalog from Sterling Electric Motors, Inc. lists prices and selection data for the more commonly used electric power drives.

17 High Vacuum Pumps. Specifications on complete line of vacuum pumps made by F. J. Stokes Corp., valuable tables of formulas, constants and conversion factors.

18 Continuous Gravimetric Feeder. Recording and integration of feed rates from a measured air signal is feature of new feeder offered by Wallace & Tiernan, Inc. Bulletin.

19 Variable Power Unit. The Varidyne Power Unit, product of U. S. Electrical Motors, Inc., is now designed with the drive motor and alternator on the same side, an important space-saving factor. Literature.

20 Forged Steel Unions. Dimensional and engineering data on the complete line of W-S forged steel unions for high-pressure service. H. K. Porter Co.

21 Grinding and Mixing Equipment. Bulletin from U. S. Stoneware includes special chapter on principles of jar, ball and pebble milling.

22 Impregnation and Blending Equipment. Young Machinery Co. offers brochure on packaged systems to formulate concentrates and to produce superior insecticide and fungicide blends.

23 Pulse Code Telemetering System. For close control of the flow of petroleum products, the "Varec" pulse code telemetering system supplies remote liquid level telemetering and handles data recording at predetermined levels. Vapor Recovery Systems Co. Literature.

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>
> ▶ **GET** *up-to-the-minute catalogs, data sheets and bulletins on new chemical products, processes and equipment.*

24 Industrial Control System Booklet. 16-page booklet from Westinghouse Electric Corp., illustrated with photographs, drawings, and circuit diagrams, discusses Cypak static control systems.

25 Removable Tube Bundle Heat Exchangers. Catalog containing all necessary design, capacity and dimension data required for selection and specification. Young Radiator Co.

26 Electronic Computer Bulletin. 6-page illustrated bulletin describing the Bendix G-15D general purpose digital computer & its digital differential analyzer accessory is offered by Bendix Computer Division, Bendix Aviation Corp.

27 Standard Storage Tanks. Detailed technical bulletin on standard storage tanks for all industrial applications. Graver Tank & Mfg. Co.

28 Non-slip Grating Surfaces. All-directional, non-slip grating surfaces, product of Bustin Steel Products, Inc., represent the ultimate in safety & durability. Bulletin.

29 Conical Scrubber Catalog. Ratings, dimensions, approximate capacities in operation contained in catalog from the Hardinge Co.

30 By-Pass Rotameter. Linear response, wide range, direct reading scale, ability to handle corrosive fluids. Bulletin from Brooks Rotameter Co.

31 Packless Valves. Complete line of packless valves for applications involving hazardous liquids & gases described in 22-page bulletin offered by Robertshaw-Fulton Controls Co.

32 Plastic Pipe, Fittings & Valves. Engineering catalog with technical & descriptive data now available from Vanton Pump & Equipment Corp. Comprehensive tables of physical & chemical properties.

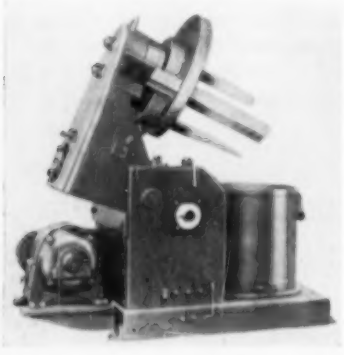
33 Industrial Periscopes. Precision-built instruments for the remote observation of inaccessible places & hazardous processes described in 4-page catalog. Lenox Instrument Co.

34 Stainless Steel Float Valves. Mechanical float valves for the control of corrosive

(Continued on page 74)

DEVELOPMENTS OF THE MONTH *(Continued)*

92 Eight-Gallon Double Paddle Mixer. A smaller size double paddle mixer suitable for small batch work in mixing paints, chemicals, inks, etc., has just been introduced by the Cincinnati Hildebrand Co., Cincinnati, Ohio. The unit is said to have almost all features found in the company's larger mixers.



The unit is heavily built, with the strength necessary to withstand strains imposed by heavy mixes. A 2 hp. motor powers the blades & can table in a close-coupled drive arrangement.

A hand tilting device to lift the paddles is balanced & pivoted for raising & lowering ease. The can cover is integral with the head & lifts out of the way when the head is raised.

Convenient lubrication points are readily accessible for ease of maintenance. All drives & gearing are enclosed for complete safety. A single, but positive, locking device holds the head down securely when in mixing position. Circle No. 92 on Data Post Card.

(Continued on page 74)

Here's the Answer...

To trouble-free pressure vessel mixing

Philadelphia "packaged" Mixers are designed for maximum adaptability to all fluid agitation applications. Standardization, high-production and complete control of all manufacturing by Phillie Gear assures you outstanding mixer performance at minimum cost.

Check these unmatched features:

1 Mechanical seal readily accessible . . . just loosen coupling bolts . . . entire shaft and impeller assembly is then independently supported . . . *no lifting equipment required* for replacement of seals.

2 Lower shaft bearing placed close to seal for minimum runout . . . separated sufficiently to prevent interleakage of lubricants.

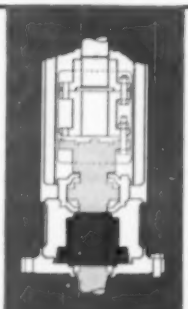
3 In-tank coupling optional . . . provided if desired for easier unit installation . . . not necessary where process conditions limit its use.

4 Seal will operate for years without maintenance . . . is designed for quick replacement as a single unit . . . retention of factory-established shaft alignment is assured.

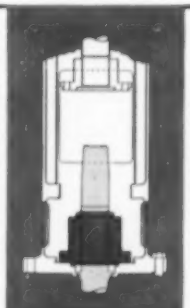
For complete information, please request Bulletin A-256.

One man and a wrench can remove and replace this new Unitary shaft seal in minutes.

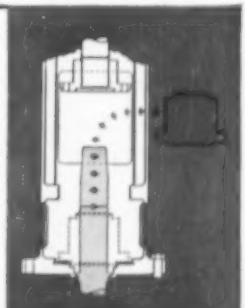
(1) Loosen lock ring at top of seal. MIXER SHAFT IS NOW FREE TO MOVE UP OR DOWN THROUGH SEAL. Next, loosen extra long bolts in lower flange of spacer coupling. Shaft drops until collar rests in cup on mixer base flange. The entire weight of lower shaft and impellers is supported by this assembly.



(2) Remove bolts and pull out spacer, thrust plate and half coupling from top of mixer shaft. Unbolt and remove top of lower bearing housing. Loosen bearing lock nut, remove bearing components and lower half of housing. Note that absolutely no lifting equipment is needed.



Remove mechanical seal assembly by simply sliding it up mixer shaft and out through opening in reducer support stand. Replace with a spare seal assembly and ship the old seal to us for maintenance.



philadelphia mixers

PHILADELPHIA GEAR WORKS, INC.

ERIE AVE. & G STREET, PHILADELPHIA 34, PENNA.

Offices in all Principal Cities

INDUSTRIAL GEARS & SPEED REDUCERS • LIMITORQUE VALVE CONTROLS • FLUID MIXERS • FLEXIBLE COUPLINGS

Virginia Gear & Machine Corp. • Lynchburg, Va.

equipment - (Cont.)

fluids. Available in 317 & 316 stainless steel & with threaded or socket welding ends. Robert Manufacturing Co.

35 Compressors & Gas Turbines. Illustrated booklet from Clark Bros. Co. describes compressors, gas turbines, power recovery turbines for the petrochemical & process industries.

36 Forged Steel Valves. 15-page brochure gives technical details, flow charts, capacity tables, etc. for complete line of forged steel valves. Velan Engineering Ltd.

37 Chlorine Evaporator Catalog. Fischer & Porter Co. will send new catalog describing their chlorine evaporator which has maximum capacity of 6,000 pounds of chlorine per day.

38 Eye Protection Equipment. 11-page catalog from Watchemoket Optical Co. Includes many types of modern safety spectacles & goggles.

39 Temperature Control Catalog. Condensed catalog of temperature controls & allied equipment for industrial heating & refrigeration. Partlow Corp.

40 Glassed Steel Polymerizers. Standard designs for temperatures up to 350° F. with internal pressures from full vacuum up to 150 or 200 lb./sq.in. Pfaudler Co. Bulletin.

41 Flat Belt Bag Conveyor. Four-page bulletin discusses advantages of new adjustable-length flat belt bag conveyor. Richardson Scale Co.

42 Traps. Thermostatic, weight-operated, piston traps for steam, air, gas, & oil. Descriptive bulletin from W. H. Nicholson & Co.

43 Blower Catalog. 60-page illustrated brochure on line of backward curved blade centrifugal fans. Booklet features performance charts. Chicago Blower Corp.

44 Turbo-Charged Gas-Engine Compressor. SLHC compressor, produced by Worthington Corp., is available in the medium horsepower range (330-880 hp).

45 Process Equipment. Fuller-Kinyon conveying systems, airslides, compressors & pumps, coolers & preheaters are described in bulletin from Fuller Co.

46 Lead-Lined & Covered Products & Equipment. World-wide service on lead products design, manufacture, installation, maintenance. Detailed 20-page bulletin from Knapp Mills, Inc.

47 Corrosion-resistant Fume Ducts & Hoods. Ceilcote Co. announces availability of Duracor plastic fume ducts as well as fume hoods, fabricated of thermosetting plastic combined with glass or with other synthetic fibers.

48 Air-conditioning Equipment. Coil surface type for industrial & commercial applications. Capacities from 41,500 to 1,680,000 Btu/hr. Niagara Blower Co. Bulletin.

49 Infrared Analyzer. New brochure on the Bichromator Analyzer offered by Perkin-Elmer Corp. Included are features & specifications of the instrument & schematic diagram of the optical layout & basic design.

50 Process Refractometer. For end point analysis & control in the chemical, petroleum, pharmaceutical & food processing fields. Bulletin. Phoenix Precision Instrument Co.

51 Laboratory Dryer. Proctor & Schwartz, Inc., offer electrically-heated dryer for low cost & close control in drying small samples.

52 Insulating Forged Steel Unions. For use in preventing electrolytic corrosion due to flow of electric current along pipe lines. 3,000-lb. class, sizes ¼-in. to 3-in. screw-end & socket-welding types. Literature from H. K. Porter Co.

53 Rotary Batch Mixer Data. Bulletin gives technical details of rotary batch mixers manufactured by Munson Mill Machinery Co.

54 Steam & Hot Water Generators. Guaranteed 80 per cent efficiency with oil or gas. Minimum installation & maintenance costs. Technical bulletin from Cyclotherm Division, National-U. S. Radiator Corp.

55 Chemical Process Equipment. Descriptive brochure on engineering & fabrication facilities of Komline-Sanderson Engineering Corp.

56 Abrasive Wheel Price & Data Book. 36-page book gives sizes, shapes, & types of grain of rubber & resinoid bonded grinding wheels used for industrial purposes. Raybestos-Manhattan, Inc.

57 Dynograph Recorder Catalog. Offner Electronics, Inc., offers 12-page catalog describing the Dynograph Recorder, a high-speed direct-writing oscillograph for the recording of a number of dynamic & static variables.

58 Equipment Selection Guide. Guide for selecting valves, boiler mountings, lubricating devices. Many tables, etc. Lunkenheimer Co.

59 Transient Converter. Fischer & Porter announce development of a transient converter for use with turbine-type flowmeters. The converter accepts a sinusoidal input signal of varying frequency & provides either an analog or a digital output. Literature.

60 Dry Materials Feeder. Low cost laboratory & pilot plant feeder operates with an accuracy of plus or minus 1 per cent deviation. Information & prices available. Vibra Screw.

61 Centralized Lubricating Systems. Literature on products & engineering facilities of the Trabon Engineering Corp.

62 Positive Displacement Metering Pump. Low-capacity, medium pressure unit, which accurately proportions various solutions or chemicals. Described in bulletin from Proportioneers, Inc.

63 Improved Triplex Pump. Can be employed where corrosive slurries of viscosities as high as 40,000 centipoises are handled at medium pressures. Literature. The Girdler Co.

(Continued on page 76)

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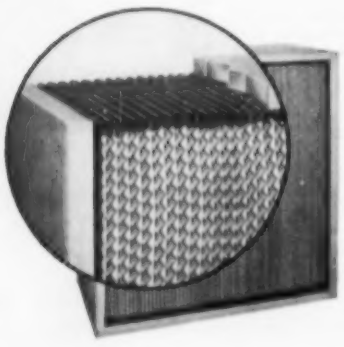
DEVELOPMENTS OF THE MONTH *(Continued)*

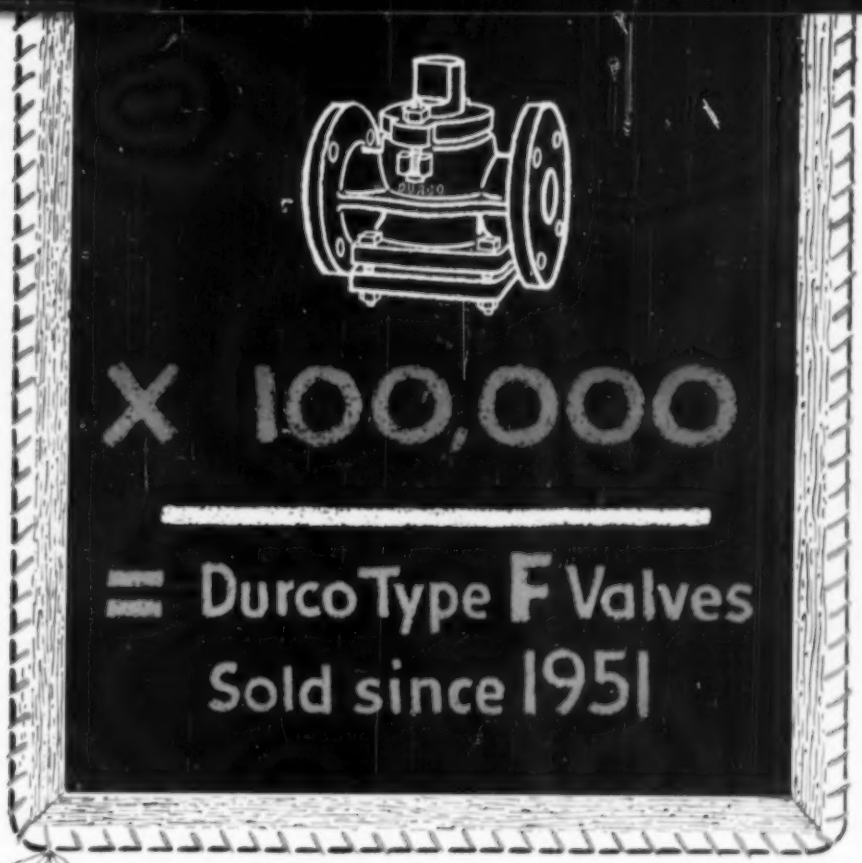
93 The Absolute Filter. The Cambridge Filter Corp. offers bulletin entitled "The Amazing Story of the Absolute Filter." This filter, which was developed for the Atomic Energy Commission for critical air cleaning problems, is said to offer the following advantages:



1. 99.95+% efficiency on particles 0.3 micron size.
2. Makes possible essentially particle-free air at reasonable cost.
3. Easily installed—no power needed—no flushing water—no drains.
4. Provides positive, trouble-free air—prevents product contamination and costly shut-downs.

Bulletin includes specifications, construction, & other technical details of these filters. Circle No. 93 on Data Post Card.

(Continued on page 76)



This "product" may solve your chemical service problems!

100,000 Durco Type F Valves in six short years is ample testimony of the performance of these valves in tough chemical service—especially when practically all of them are *still in service*.

With the recent introduction of the 3-inch size, Durco Type F Valves (¼" through 3", inclusive) offer the broad size range needed for a large majority of applications. Their simple design and the corrosion resistance of Durco alloys and Teflon sleeves extend their versatility.

Full details in free Bulletin V/4b.

Manufactured under one or more of the following patents. U. S. Patent Nos. 2713987, 2729420, 2735645, 2728550. Patented in Canada, 1955, No. 519424.

DURCO
CORROSION RESISTING ALLOYS & EQUIPMENT

THE DURIRON COMPANY, INC., DAYTON, OHIO

Branch Offices: Atlanta, Baltimore, Boston, Buffalo, Chicago, Cleveland, Dayton, Detroit, Houston, Knoxville, Los Angeles, New York, Philadelphia and Pittsburgh.

services-

69 Free Laboratory Facilities. The Fletcher Works announce that they will make available to any chemical, pharmaceutical, food processing, or textile manufacturing firm their full laboratory facilities without charge.

70 Water Analysis Service Bulletin. 100-page bulletin from Solvay Process Division, Allied Chemical & Dye Corp., contains numerous tables of analytic data, conversion factors, & turbidimetric & color standards. Also section on preparation of reagents, indicators & standard solutions for analysis.

71 Sulfuric Acid Handling Chart. Up-to-date instructions for safe unloading & handling of sulfuric acid presented on 17- by 22-in. wall chart. Olin Mathieson Chemical Co.

72 Paint Testing. Crippen & Erlich, subsidiary of Foster D. Snell, announce revised price schedule for various paint tests. Prices cover physical qualities, chemical properties, permanence properties, & some comprehensive tests.

materials-

73 Fiberglas-Polyester Laminates. "Lamicor," as a structural material, offers a unique combination of important thermal, electrical, chemical, & mechanical properties. Bulletins from Owens-Corning Fiberglas Corp.

74 Selector Guide for Alloy Metals. Techalloy Co., Inc., offers chart on comparative strength at high temperatures, scaling resistance, individual characteristics, & comparative prices.

75 Silicone Rubber Instruction Booklet. New 28-page data sheet & compounding study on Union Carbide W-96 Silicone Rubber Gum Stock provides detailed information & instructions for manufacturers, fabricators, & product designers. Many tables & charts.

76 Thin-walled Welded Tubing. Universal Tube Corp. offers light-gauge tubes in continuous lengths up to 200 feet. Complete information available from manufacturer.

77 Technical Bulletin on Tetrapotassium Pyrophosphate. Revised & expanded publication from Westvaco Mineral Products Division, Food Machinery & Chemical Corp., lists typical analysis & properties; rate of solution; & vapor pressure of hydrates. Also industrial applications.

78 Properties of Teflon. Haveg Industries offer 4-page brochure which treats Teflon as a material.

79 Aluminum Jacketing Bulletin. 38-page bulletin from Kaiser Aluminum devoted to materials & methods for aluminum jacketing.

80 Aluminum Oxide Protective Coatings. Linde Air Products Co. announces adaptation of their "Flame-Plating" process to aluminum oxide coatings. The coating is claimed to have excellent resistance to chemical attack & high temperature as well as desirable mechanical properties.

81 Technical Bulletin on Sulfamic Acid. Exceptionally complete description of properties of sulfamic acid (30 pages). Many charts and tables.

82 Tenox Antioxidants. 4-page folder charting structural formulas, properties, composition & application of the various Tenox antioxidants is offered by Eastman Chemical Products, Inc.

83 Dimethylformamide. Now available as a high-purity reagent-grade solvent from Fisher Scientific Co.

84 Essential Oils-Aromatic Chemicals. Wholesale price list from Fritzsche Brothers, Inc.

85 Dry Film Lubricant. Molykote Type 174X is formulated especially for drawing & forming of titanium, titanium alloys, chromium, & stainless steels at elevated temperatures. Alpha Molykote Corp.

86 Expanded Foam Polyethylene. Agilene-F is described in detail in new catalog sheet published by the American Agile Corp. Numerous charts & graphs.

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▶ **GET** *up-to-the-minute catalogs, data sheets and bulletins on new chemical products, processes and equipment.*

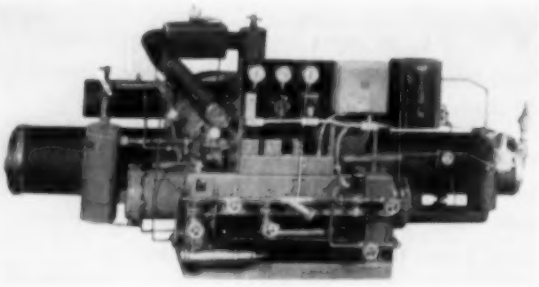
Developments of the Month (Continued)

95 Complete Process Instrument Catalog. Fischer & Porter offer a new 32-page catalog describing the company's products which are available for "immediate shipment."

The new catalog, which includes prices, covers indicating, recording, controlling, & transmitting instruments for flow, pressure, & density. Many tables, charts, & a wealth of technical data for instrument selection purposes make this a most useful booklet. Circle No. 95 on Data Post Card.

DEVELOPMENTS OF THE MONTH (Continued)

94 Packaged Liquid Coolers. A new line of packaged liquid coolers is being introduced by the Doyle & Roth Manufacturing Co. The coolers, which employ the flooded refrigeration principle, are of special multi-pass design & may be used effectively for handling viscous or slurry type liquids.



The package includes a complete refrigeration cycle, compressor, motor & starter, refrigerant controls, liquid cooler, condenser, piping, wiring & insulation, shop assembled & tested, ready for quick installation & immediate operation. The units are available in a range of sizes from 5 to 100 hp.

Advantages of flooded coolers over dry expansion type evaporators are said to be:

1. Higher rate of heat transfer because most of the refrigerant in the shell is a liquid rather than a wet gas mixture with a high gas content.

2. None of the heat transfer surface in the shell is required for superheating; hence all of the available surface is utilized for vaporization of the liquid refrigerant.

3. Since the fluid to be cooled passes through the tubes & the heads, it is possible to clean the tubes whenever necessary & thus maintain a clean surface with a high rate of heat transfer. Circle No. 94 on Data Post Card.

FUTURE MEETINGS and Symposia of the Institute

MEETINGS **SYMPOSIA**

■ **WHITE SULPHUR SPRINGS, W. VA.**

March 3-6, 1957. Greenbrier Hotel.

For complete technical program see page 84 of this issue.

■ **PHILADELPHIA, PA.**

March 11 through 15, 1957.

EJC Second Nuclear Engineering and Science Congress & Exposition. (See page 90.)

■ **EVANSTON, ILL.**

April 8-10, 1957. Northwestern University.

Plant instrumentation symposium sponsored jointly by A.I.Ch.E. (Dave Boyd, Universal Oil Products Co., Des Plaines, Ill., chairman) and the Instruments & Regulators Div. of A.S.M.E. On the afternoon of April 9 there will be a session devoted to the dynamics of processes with Page Buckley, DuPont, presiding. Other sessions will be on application of automatic controls.

■ **ST. LOUIS**

June 3-7, 1957.

Golden Jubilee Meeting, Air Pollution Control Association; sponsoring societies include A.I.Ch.E. (Tuesday, June 4 will be A.I.Ch.E. day.)

Methods of Analysis; Instrumentation; Atmospheric Reactions, Photochemical & Other; Aerosol Formation & Control; Progress in Air Pollution Control Equipment & Methods; and Human & Economic Goals for Engineers in Air Pollution Control will be treated.

For information contact W. L. Faith, Managing Director, Air Pollution Foundation, 704 S. Spring St., Los Angeles 14, California.

■ **SEATTLE WASH.**

June 9-12, 1957. Olympic Hotel.

TECHNICAL PROGRAM CHAIRMAN: James G. Knudsen, Dept. of Chem. Eng., Oregon State College, Corvallis, Oregon.

Industry's Role in University Programs on Nuclear Engineering

CHAIRMAN: John Kaufmann, Div. of Reactor Development, U. S. Atomic Energy Commission, Wash., D. C.

Chemical Engineering Data and Calculation Methods

CHAIRMAN: W. C. Edmister, Calif. Research Corp., Richmond Laboratory, Richmond, Cal.

Filtration

CHAIRMAN: F. M. Tiller, University of Houston, Houston 4, Texas.

Electrochemical Engineering

CHAIRMAN: Joseph Schulein, Dept. of Chem. Eng., Oregon State College, Corvallis, Oregon.

(*Continued on page 78*)

ARE YOU RESPONSIBLE FOR MEASUREMENT OF FLUID FLOW?

Gentile FLOW TUBES

are impact-type head meters or differential producers.

They are designed to give you guaranteed high accuracy with lowest head loss.

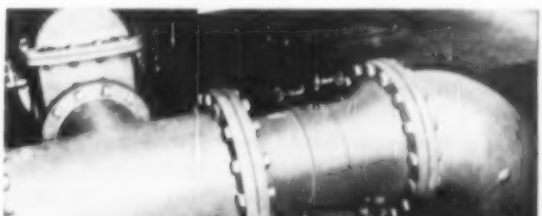
*Gen-Ti-ly

You also get:

LOW FIRST COST—Gentile Flow Tubes are economical to purchase.

LOW OPERATING COST—Gentile Flow Tubes require minimum maintenance. Where purging or back-flushing is a normal routine, the Gentile Flow Tube can be arranged for constant or intermittent purging without removing from the line.

LOW INSTALLATION COST—Gentile Flow Tubes can be installed with no straight run upstream or downstream, except where near valves or regulators.



Actual installation of a 16" Flow Tube for REVERSE FLOW. Note fittings (elbow and tee) are bolted directly to flanges of Flow Tube.

Gentile Flow Tubes can be furnished with or without suitable secondary indicating, recording, or totalizing instruments.

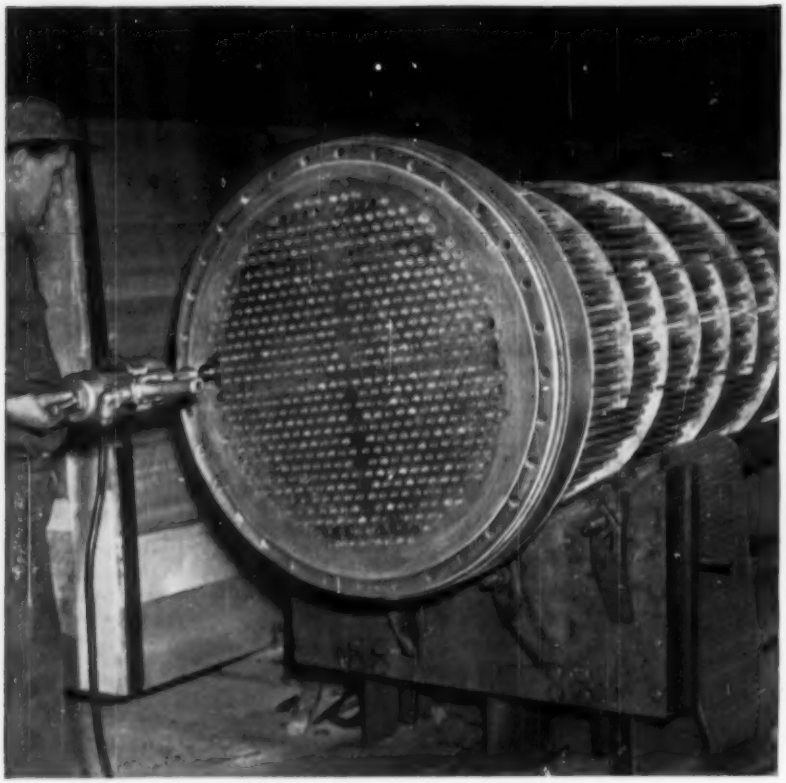
GENTILE Flow tubes are manufactured exclusively by Foster Engineering Company

Write for further information or specific recommendations.

FOSTER ENGINEERING COMPANY

835 LEHIGH AVENUE, UNION, N. J.

AUTOMATIC VALVES • CONTROL VALVES • SAFETY VALVES • FLOW TUBES



Tricky assembly job handled with ease...at Downingtown

Specs said: Roll type 329 stainless tubes into type 316 and 304 tube sheets. A tricky problem, since the 329 tubes are 15-20 points harder on the Rockwell B scale than the 304 and 316 tube sheets.

What's more, an alert suggestion saved our customer the cost of a test shell, by utilizing the annulus created by the specified double tube sheet construction.

Design Pressure: Shell —125 psi at 300° F.
Tubes— 75 psi at 300° F.

Hydrostatic Test Pressure: 150 psi

Construction: Per ASME Code, Para. U-69...Customer Inspected

Tubes: 608 Stainless Steel Tubes, Type 329 (Carpenter #7MO)
¾" O.D. x 16 ga. x 15' 9" L.
Outer Tube Limit: 30⅝"...4 Pass

Floating Tube Sheets: Two—1½" and 2" thick...32⅞" O.D.

Fixed Tube Sheets: Two—1¼" and 1¾" thick...38⅜" O.D.

Shell Side Tube Sheets: Stainless Steel, Type 304.

Tube Side Tube Sheets: Stainless Steel, Type 316.

Write for helpful heat exchanger design data—Bulletin HE.

Downingtown Iron Works, Inc.
106 Wallace Ave., Downingtown, Pennsylvania
division of PRESSED STEEL TANK COMPANY Milwaukee
Branch offices in principal cities

HEAT EXCHANGERS—STEEL AND ALLOY PLATE FABRICATION
CONTAINERS AND PRESSURE VESSELS FOR GASES, LIQUIDS AND SOLIDS

FUTURE MEETINGS and Symposia of the Institute

(Continued from page 77)

MEETINGS **SYMPOSIA**

Chemical Engineering in the Pulp and Paper Industry

CHAIRMAN: J. L. McCarthy, Dept. of Chem. Eng., Univ. of Washington, Seattle, Washington.

■ **STATE COLLEGE, PA.**

August 11-14, 1957. Pennsylvania State University.

First National Conference on Heat Transfer, featuring Applied Heat Transfer. Sponsors: A.I.Ch.E., A.S.M.E., & College of Eng. & Arch., Penn State Univ.

James N. Addoms, Atlas Powder Co., Wilmington 2, Delaware, is A.I.Ch.E. program chairman.

■ **BALTIMORE, MD.**

September 15-18, 1957. Lord Baltimore Hotel.

TECHNICAL PROGRAM CHAIRMAN: R. L. Copson, Mutual Chemical Co. of America, 1348 Block St., Baltimore 31, Maryland.

General Committee and operating committees have completed initial organization and are now functioning. Technical Program symposia will be decided on early in 1957. Approximately 14 plant trips have been suggested. Additional emphasis on student activities is one of the planned features.

Drying

CHAIRMAN: Ralph E. Peck, Chem. Engineering Dept., Ill. Inst. of Tech., Chicago 16, Ill.

Low Temperature Processing

CHAIRMAN: Clyde McKinley, Air Products, Inc., P. O. Box 538, Allentown, Pa.

Direct Operating Labor Costs

CHAIRMAN: John Happel, Chem. Eng. Dept., New York University, University Heights, N. Y. 53.

■ **ANNUAL—CHICAGO, ILL.**

December 8-11, 1957. Conrad Hilton Hotel.

TECHNICAL PROGRAM CHAIRMAN: Henry F. Nolting, Standard Oil Co., 2400 New York Ave., Whiting, Ind.

Fluidization of Solids

CHAIRMAN: E. R. Gilliland, Chem. Eng. Dept., M.I.T., 77 Massachusetts Ave., Cambridge 39, Mass.

Flow characteristics, rate of entrainment and heat transfer; fluidized reactors vs. fixed and moving bed reactors.

Effective Cost Control in Process Operations

CHAIRMAN: C. W. Nofsinger, The C. W. Nofsinger Co., 906 Grand Ave., Kansas City 6, Mo.

Evaluation of Projects from the Original Idea to the Investment Stage

CHAIRMAN: C. W. Nofsinger (see above).

Chemical Engineering Abroad

CHAIRMAN: Shelby Miller, Chem. Eng. Dept., University of Rochester, River Campus Station, Rochester 20, N. Y.

Corrosion Resistant Alloy Materials of Construction

CHAIRMAN: G. Fred Ours, Carbide and Carbon, Charleston, W. Va.

(Continued on next page)

Laboratory and Pilot Plant Techniques

CHAIRMAN: G. W. Blum, The Goodyear Tire & Rubber Co., 1485 E. Archwood Ave., Akron 16, Ohio.

■ **SALT LAKE CITY, UTAH**

September 21-24, 1958.

TECHNICAL PROGRAM CHAIRMAN: E. B. Christiansen, Dept. of Chem. Eng., Bldg. 437, Univ. of Utah, Salt Lake City, Utah.

UNSCHEDULED SYMPOSIA

Correspondence on proposed papers is invited. Address communications to the Program Chairman listed with each symposium below.

- **Centrifugation:** James O. Maloney, Dept. of Chem. Eng., U. of Kansas, Lawrence, Kans. The theory and quantitative aspects of centrifugation.
- **Size Reduction:** Edgar L. Piret, Chem. Eng. Dept., U. of Minnesota, Minneapolis 14, Minn.
- **Filtration & Centrifugation:** Horace Hinds, Jr., Corn Products Refining Co., Box 345, Argo, Ill.
- **Chemical Engineering Process Dynamics as They Affect Automatic Control:** David M. Boyd, 315 Ridge Ave., Clarendon Hills, Ill.
- **Ethylene Manufacture:** Hermann C. Schutt, 201 Devonshire St., Boston 10, Mass.
- **Dry Classification of Solids:** D. W. Oakley, Metal & Thermit Corp., Carteret, N. J.
- **Saline Water Conversion:** W. L. Badger, 309 So. State Street, Ann Arbor, Michigan.
- **Statistics in Chemical Engineering:** John C. Whitwell, Princeton University, Princeton, N. J.
- **Education of Chemical Engineers:** F. M. Tiller, Dean of Eng., University of Houston, Cullen Blvd., Houston 4, Texas.
- **New Chemical Engineering Construction Techniques:** S. A. Guerrieri, The Lummus Co., 385 Madison Ave., N. Y. 17.
- **Mineral Process Engineering and Mineral Economics:** L. A. Roe, International Minerals & Chemical Corp., 20 North Wacker Drive, Chicago 6, Ill.
- **Foams and Froths:** J. L. York, Ramo-Wooldridge Corp., 8820 Bellanca Ave., Los Angeles, Calif.
- **The Threatened Imbalance Between Chlorine and Alkali in American Chemical Industry:** Zola G. Deutsch, Deutsch & Loonam, 70 E. 45th St., New York City 17.
- **Shock Waves in Process Equipment:** Chairman to be named.
- **Scale-Up Philosophy in the Chemical Industry:** Chairman to be named.
- **Start-Up of New Chemical Plants:** Chairman to be named.
- **Computers in Optimum Design of Process Equipment:** Chen-Jung Huang, Dept. of Chem. Eng., Univ. of Houston, Cullen Blvd., Houston 4, Texas.

LOCAL SECTION MEETINGS

■ **TWIN CITIES**

January 31, 1957. Hotel Nicollet, Minneapolis, Minn.

(*Continued on page 80*)

. . . C-R CHILL-VACTOR UNITS

Chemical and food processors are discovering that during the summer it is possible to use excess winter steam capacity for extremely economical water chilling, using a Croll-Reynolds steam-jet CHILL-VACTOR system.

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The PERFECT SEAL

DURAMETALLIC CORPORATION

KALAMAZOO MICHIGAN

FUTURE MEETINGS

(*Continued from page 79*)

■ **TWIN CITIES, ONE DAY MEETING**

January 31, 1957.

Morning—

Session No. 1: Chemical Marketing in the Upper Midwest.

The Role of Research in the Development of Chemical Markets.

The Role of Advertising in the Development of Chemical Markets.

The Organization of the Archer-Daniels-Midland Development Department.

The Relation of Market Research to Chemical Marketing.

Where Chemicals Are Used in the North Central U. S.

Session No. 2:

Applied Chemical Engineering in the Paper Industry.

Permeability and Absorption Studies of Epoxy Films.

Mechanical Seals for the Chemical Industry.

The Rural Cooperative Power Association Reactor.

Afternoon—

Session No. 3: Automation in the Chemical Industry.

The Nature of Digital Computers.

Digital Techniques in Chemical Processing.

Automation in Process Control.

Process Control in the Refining and Bleaching of Soybean Oil and Lecithin.

Session No. 4: What I Do in My Job as a Chemical Engineer.

Contact W. J. Manske, co-chairman of publicity committee, Minnesota Mining and Manufacturing Co., 900 Fauquier Ave., St. Paul 6, Minn.

AUTHOR INFORMATION

Submitting Papers

Procedure to be followed is, in brief:

1—Obtain four copies of "Proposal to present a paper before the A.I.Ch.E.," plus one copy of "Guide to Authors" from Secretary, A.I.Ch.E., 25 West 45th St., New York 36, N. Y.

2—Send one copy of completed form to Technical Program Chairman for meeting selected from above list.

3—Send another copy to Mr. E. R. Smoley, The Lummus Co., 385 Madison Ave., New York 17, N. Y. (Asst. Program Comm. chairman).

4—Send third copy to Editor, Chemical Engineering Progress, 25 West 45th St., New York 36, N. Y. Paper will automatically be considered for possible publication in A.I.Ch.E. Journal.

5—If desired to present paper in a selected symposium, send fourth copy to chairman of the symposium.

6—Prepare five copies of manuscript. Send one copy each to Symposium chairman, Technical Program chairman, or both copies to former if no symposium is involved. Other three copies should be sent to Editor, C.E.P. Presentation at meeting offers no guarantee of acceptance for publication.

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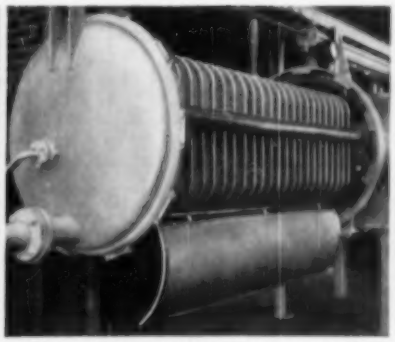

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Planning your March, '57 training for the future . . .

The month of March will offer unusual opportunities for chemical engineers to take part in A.I.Ch.E.-sponsored seminars, paper presentations, and equipment exhibitions on subjects of pertinence to the future of the chemical process industries, as well as to the profession. Registration and reservation cards and program information will be mailed soon to members from the executive secretary's office, or may be had by checking the special boxes on the Data Service post cards on page 65.

March 3-6

A. I. Ch. E. Spring Management Conference . . .

In the chemical and related industries, major projects are often decided on a basis of two or three years to design and get on stream, plus seven or eight years before obsolescence of process or product takes its toll. This adds up to around ten years that management must think ahead in order to be reasonably certain that their projects will pay off. The purpose of the A.I.Ch.E. Spring Management Conference is to bring to the attention of chemical engineers some of the best opinion as to what they and their company associates can expect in futures in labor, raw materials, products, and processes interpreted into the special case of the chemical industry "complex." In addition, special training in group dynamics, practical use of computers in chemical company control, and a discussion of the effect licensing is having on practice, will take place. For details of the program, turn to page 84.

- LABOR FUTURES ☐
- MATERIALS FUTURES ☐
- GROUP DYNAMICS ☐
- COMPUTERS ☐
- LICENSING ☐

March 11-15

2nd Nuclear Congress & A. I. Ch. E.'s Atomic Exposition . . .

Chemical engineers have, in connection with nuclear projects, developed a considerable amount of processing and operations information which is translatable into nonnuclear applications. Likewise, a great deal of experience has been compounded in the carrying on of chemical engineering operations in the presence of radiation necessitating special precautions, inducing reactions, or physically affecting materials of construction. Recent declassification is making available at the 2nd Congress an informative program, comprehensive enough to enable each chemical engineer to plan a selection of subjects to fit his particular needs. The Exposition will offer an outstanding opportunity to actually see the newer specialized equipment required. Next month, *CEP* will present the detailed Congress program, floor plan, and classified listing of exhibitors. *CEP* will then prepublish selected Congress papers to promote study preliminary to attendance. For final program description turn to page 90.

NUCLEAR FUEL

- PREPARATION ☐
- REPROCESSING ☐
- CONTAINMENT ☐

NUCLEAR PROCESSING

- HAZARDS ☐
- INSURANCE ☐
- MARKETS ☐
- LEGISLATION ☐

Final details for A.I.Ch.E.'s

If your destiny in the affairs of management can benefit from new ideas, new factual information on trends affecting the process industries for the next 10 years, better make plans with the wife right now to be at the Greenbrier March 3-6 for A.I.Ch.E.'s Spring Management Conference.

Here are the convincing arguments that should clinch your plans: Projections will be made by outstanding experts on changes resulting from rising shortages of labor, effects of shifting advantages and availabilities of raw materials, and changing markets and marketing methods for processed materials. The rising awareness that groups or teams don't usually function with maximum creativity is behind a session that will provide training in some of the latest techniques in practical group dynamics. Modern accounting practices using computers—which in effect rate the profitability of processing ventures—will be described with particular emphasis on the factors which are capable of having pronounced effects on how good the results look. Finally (but first on the program) the effect of professional registration on the practice of chemical engineering by individuals and corporations will be aired by a panel.

Fabulous Greenbrier

Modern management-man's retreat from the subjective nerve-jangling of daily routine, the Greenbrier is idyllically located, equipped for bringing together people who can exchange ideas, relax in both creative thinking and play. As taken over by the Central Virginia Section for the chemical engineers, the Greenbrier will represent a union of forces: retention of the luxurious customs (sports clothes by day, many wear black tie & cocktail dresses by night), plus the friendly informality and good-natured banter of chemical engineers wherever, whenever, they get together.

What Motivated These Sessions

LABOR

There is serious doubt that supply can keep up with the tremendous rate of expansion of the process industries. Costs are expected to rise—but how much, and what effect will this have on prospects of profitability? Automation will provide a partial answer, but with problems. How management, government, unions look upon these problems will be tied together in this one session.

Vital to any projection of labor is the matter of who is doing the forecasting. Brown, of M.I.T.'s Sloan School of Industrial Management (presiding) has been close to the National Industrial Conference Board fact-gathering activities. Forrest Kirkpatrick, now in top management in steel, has long been a professor, government advisor, and arbitrator. One of the nation's top professional women, Aryness Wickens is deputy commis-

THE MEETING PROGRAM

SUNDAY, MARCH 3

THE IMPACT OF LICENSING ON CHEMICAL ENGINEERING—A PANEL DISCUSSION, T. J. Carron, Director, Employee Training and Development, Ethyl Corp., Detroit, Mich., presiding.

Members of the panel will each speak briefly on one aspect of the subject before the meeting is opened to informal discussion.

W. W. Hodge, Mellon Institute—Legislative and enforcement trends in engineering registration.

B. B. Kuist, Fluor Corp.—Licensing as it affects the practice of engineering by corporations.

E. T. Neill, Dow Chemical—Licensing as it affects professional development and morals in an engineering department.

G. G. Brown, Univ. of Michigan—Licensing as it affects consulting practice; responsibilities of educators in the licensing movement.

SPECIAL NOTE: Something new—a "big" symposium on Labor-Management Relations of the Future. See text following.

MONDAY, MARCH 4

COMPUTERS IN CHEMICAL COMPANY CONTROL, W. M. Carlson, DuPont, Newark, Del., presiding.

While attention has been paid to the use of computers in chemical engineering technology, little has been said on the use of computers in managing chemical businesses. This symposium will do just that—review the accounting and management methods being developed with the aid of modern computers.

Integrated Data Processing—The Fundamental Input Medium for Computer Applications, W. A. Crichly, controller, Diamond Alkali, Cleveland, O.

Details of techniques and equipment utilized in the preparation of problems for and their solutions in the Diamond Alkali integrated data processing system.

Prerequisites for Computer Applications, H. A. Hashbarger and N. L. Sample, Production and Control, Organic Chem. Div., Monsanto, St. Louis, Mo.

Monsanto's experience with the IBM 702-EDPM since its installation in Feb. 1955. Present and projected use of the machine in management control and accounting. Advantages and beneficial results which have been achieved, difficulties encountered, and the preparations necessary for translating existing company control techniques onto computer programs.

Computer Applications to Management Cost Accounting, R. L. Hershey and C. R. Schwartz, Gen. Manager and Control Manager, Polychemicals Dept., Du Pont, Wilmington, Del.

An accounting technique known as "cost roll up" and related information provides a satisfactory basis for achieving management's three major control objectives: 1) prompt data; 2) data giving an overall look at the unit under management's direction; 3) comparison of the data to predetermined goals to provide a sound basis for corrective action. Cost roll up procedures require rapid handling of masses of accounting data and this makes the use of a computer desirable.

Present and Prospective Use of Computers in Management Control, R. H. Gregory, Sloan School of Industrial Management, MIT, Cambridge, Mass.

Computers are now used primarily for after-the-fact processing, such as payroll, in-

By J. Grossman and C. L. Dorsey, Jr. | Du Pont, Waynesboro, Va.

FOR YOUR WALLET
A.I.Ch.E. National Meeting
White Sulphur Springs, W. Va.
Greenbrier Hotel, March 3-6, 1957
First Session: 9:15 A.M. Monday
Last Session: 2:00 P.M. Wednesday
Banquet: 7:00 P.M. Tuesday
American Plan Rates: $40, twin bedroom and bath for two; $28, same room for one; $22 for single.

Spring Management Conference at *The Greenbrier*

sioner of the Bureau of Labor Statistics, is a specialist in economics (went through depression) and labor statistics, has advised Congress, highest international groups. Jack Knight, who started his career in the refining industry, is one of organized labor's outstanding spokesmen.

RAW MATERIALS, PRODUCTS, PROCESSES

Here are a few highlights: biologicals by tissue culture techniques (a la Salk vaccine), new materials to war on viruses (which means new production problems and methods for chemical engineers). Plastics: now a $1 billion market, predicted to double by 1961, what about the big four raw materials (ethylene, vinyl chloride, butadiene, styrene) by 1965? For coal chemicals, perhaps new sources, new methods—coal cannot keep pace with demand. Inorganics resurge: rare earths, metals, high-energy fuels, and a lot of other new developments. For organics, a diminishing role for agricultural raw materials and coal, increasing load for petroleum, changes in processes may be in offing.

Design engineers are trending to higher and lower pressures and temperatures, new construction materials, new energy sources.

Marketers are becoming aware that only extreme mobility will keep one's firm up with competition through these next 10 years.

To be ahead in 1965 will require a lot of changes—*now* is the time to prepare. The Futures in the Chemical Industry symposia will give you the know-how.

TEAMWORK

Build a top-flight team of engineers, executives, scientists—get no creativity, no real cooperation. Have a properly oriented team, get good results. Management announces better plan, result: resistance. Creative-thinking engineers and executives—no chance to get ideas into use. Excellent production team—not working together. What's wrong? Human factors have not been taken into account. How to do it? Get answers, group techniques in Scientists, Engineers and Management Decisions—A Problem in Teamwork symposium.

PLANNING & MANAGEMENT'S USE OF COMPUTERS

Accounting department produces evaluation of engineering projects. Taxes, depreciation, capital *vs.* expense allocations—all affect profitability of an engineering project. From process design economics to document before board of directors for final decisions, middlemen influence the engineering project picture. Is the chemical engineer aware of all these factors? Are you aware of industrial management control procedures, of computer methods used, calculating methods?

(*Continued on page* 101)

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ventory, customer billing, statistical and cost analysis, etc. At some future time a wholly-integrated or comprehensive approach to data processing and management information may be developed. Probable consequences will be: fewer reports with a higher information content, selection of a course of action from simulated results of various operating rules, further improvement of decision-making rules, and analysis of the whole system itself.

SCIENTISTS, ENGINEERS AND MANAGEMENT DECISIONS—A PROBLEM IN TEAMWORK, G. D. Creelman, Creelman Associates, Cleveland, O., presiding.

Teams may lose much effectiveness because of frustration involved in trying to reconcile divergent viewpoints; valuable conclusions reached by the team may never affect managerial practice because of human resistance to new ways. This symposium will discuss the nature and origins of such problems and suggest solutions.

The Nature of Teamwork in Decision-Making, R. W. Wallen, Creelman Associates, Cleveland, O.

Assembling a group of people and giving them a problem does not insure that they will develop into an effective team. Such groups may be helped to be more effective through training in the development of adequate data and the recognition and handling of emotional forces so as to bring about a highly creative outcome.

Translating Decisions into Action, E. W. Burr, Manager, Personnel Development, Monsanto, St. Louis, Mo.

To insure the acceptance of changes resulting from management decisions, we must recognize and deal with the forces that make people resist reasonable changes, such as: possible loss of prestige, decreased opportunity for advancement, fear of handling the new way well, resentment of being "manipulated," etc. To deal with these resistances the use of methods including participation formulation, logical presentation, and "gripe" sessions are necessary.

Teamwork in Production, C. C. Van der Wall, Director of Manufacturing, Ansul Chemical Co., Marinette, Wisc.

The application of some of the known psychological principles to the problem of

(*Continued on page 86*)

For further information on this meeting, check the request box on the Data Service Post Card, page 65.

Covington Plant of Industrial Rayon Corp. is one of two plant trips planned for Monday and Tuesday. Other plant is the sulfite paper plant of West Virginia Pulp and Paper Co.

PAUL O. ABBÉ'S

New
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VACUUM
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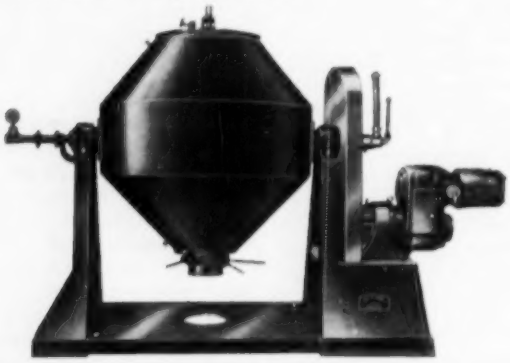

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—Volatile solvents are condensed & recovered.
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PAUL O. ABBÉ

271 Center Avenue Little Falls, New Jersey

WHITE SULPHUR PROGRAM

Fishing, just one of the Greenbrier's sports.

(Continued from page 85)

managing a medium-sized company (550). The basic management philosophy, termed "participative" management, will be presented, and the whole management program will be related in such a way as to illustrate how social science research findings in "techniques that produce teamwork" are used in everyday, on-the-job relationships. An example problem illustrates differences in "readiness" of people, dangers, effect of training.

Keeping Centers of Creativity Alive in a Large Organization, O. A. Ohmann; Standard Oil Co. (Ohio), Cleveland, O.

Increases in productivity will continue to depend principally on combinations of creative innovation and enterprise. Rigidities of large business organizations can be the natural enemies of creativity. We must now re-examine and redefine the function of the administrator not only in terms of executing an idea, but in terms of providing the structure and climate within which the innovators in both technology and market action can be brought closer together again.

Panel Discussion, E. W. Burr, G. D. Creelman, O. A. Ohmann, R. W. Wallen, C. C. Van der Wall, F. J. Curtis, president, Monsanto, St. Louis, Mo.

TUESDAY, MARCH 5

FUTURE LABOR TRENDS IN THE CHEMICAL INDUSTRY, E. R. Smoley, vice president, The Lummus Co., Chmn.; D. V. Brown, Sloan School of Industrial Management, MIT, presiding.

Changes in the labor picture over the next ten years. The speakers will cover such subjects as fringe benefits, changes in government policies, changes in wages, total employment, union membership, and the form of union contracts.

Business Views The Future, F. H. Kirkpatrick, asst. to the president, Wheeling Steel Corp., Wheeling, W. Va.

Government Views The Future, A. J. Wickens, Deputy Asst. Sec. for Employment and Manpower, U. S. Dept. of Labor, Washington, D. C.

Labor Views The Future, O. A. Knight, president, Oil, Chemical and Atomic International Union, AFL-CIO, Denver, Colo.

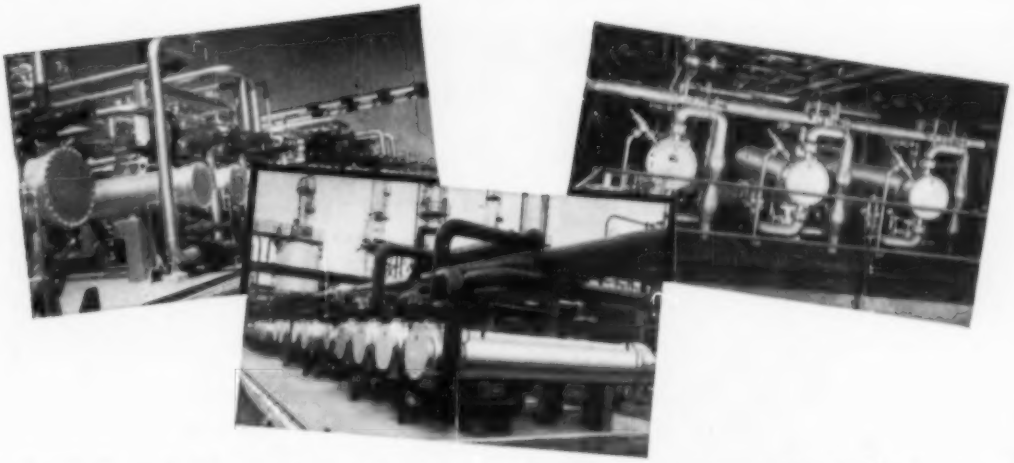
Discussion

WEDNESDAY, MARCH 6

FUTURES IN THE CHEMICAL INDUSTRY—I, R. E. Chaddock, Hercules Powder Co., Washington, Del., presiding.

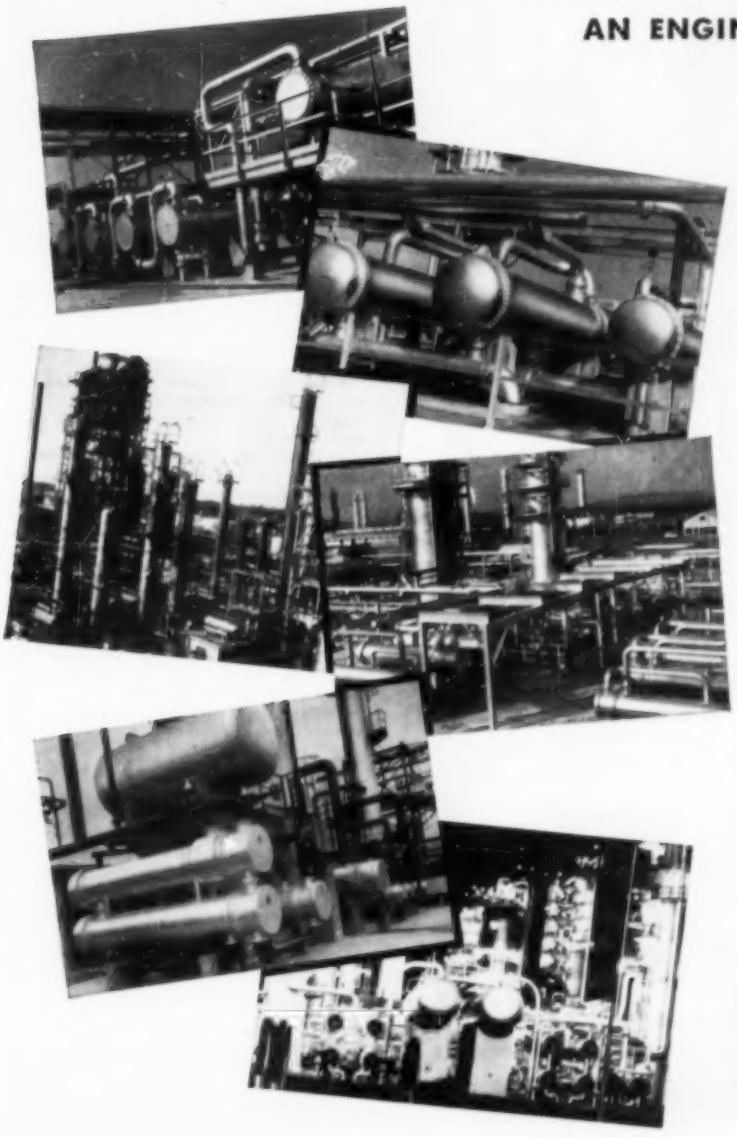
In this symposium the future status of cer-

(Continued on page 88)



what heat transfer characteristics are needed here...and why?

AN ENGINEERED ANSWER FOR YOU



In substance, and in nearly every instance, that's the question that's put to Ross.

It can apply to chemical processing, petroleum refining, power generation or nuclear energy... wherever specialized heat exchangers are indicated.

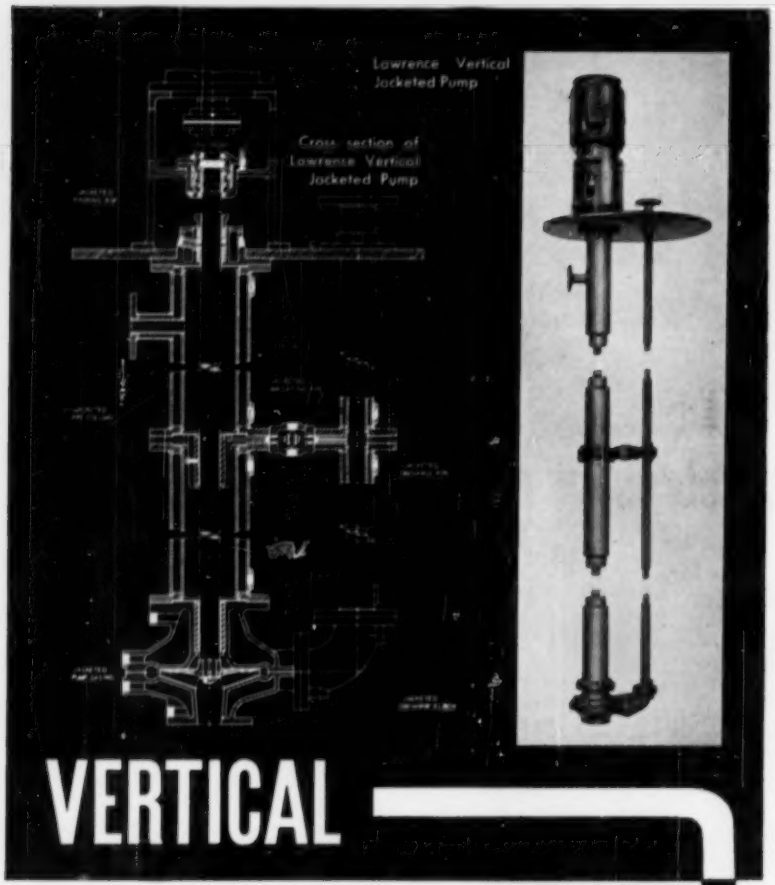
It may call for a highly complex design, high temperature or high pressure construction, special materials... a single unit or dozens of identical ones.

The point is that whatever the requirements, Ross will present you with a thoroughly considered, engineered answer. No one is more qualified to give it. No one is better equipped to deliver the finished product.

When you come to Ross for the engineering solution, of this you can be certain: your questions or those of your consultants will be answered with well qualified "reasons why," based upon vast experience in the specially engineered shell and tube heat exchanger field. Your inquiry will bring a nearby Ross representative promptly to your desk.

Ross Heat Exchanger Division of American-Standard, Buffalo 5, N.Y. In Canada: American-Standard Products (Canada) Limited, Toronto 5, Ont.

ROSS



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Lawrence vertical jacketed pumps are designed to pump liquids such as sulphur, phthalic anhydride, resins, waxes, etc., which tend to solidify or become viscous at low temperatures. The heating medium can be steam, dowtherm, etc.

The pump is jacketed throughout, i.e. — the pump casing, pipe column, discharge pipe and packing box. All heating spaces are vented and self-draining.

For submerged operation, these pumps are frequently made with only the pipe column, discharge pipe and packing box jacketed; the pump itself, not being jacketed.

If you have to pump liquids which must be maintained above a certain temperature to prevent solidification, write us the pertinent details. No obligation.

Write for Bulletin 203-7.

LAWRENCE PUMPS INC.
371 Market Street, Lawrence, Mass.

WHITE SULPHUR PROGRAM

Scene from Tuesday night's production of the Broadway hit *The Rainmaker*.

(Continued from page 86)

tain segments of the chemical industry and related areas will be discussed from a 1965 viewpoint. These include new products, new processes, new markets, and the growth of the industry.

The Future for Drugs and Biochemicals, A. J. Greene, Administrative vice president, Chas. Pfizer & Co.

The Future for Plastics, Roger Williams, Jr., Roger Williams Technical and Economic Services, Inc., N. Y.

The Future for Coal Chemicals, J. Pursglove, vice president, Pittsburgh Consolidation Coal Co., Pittsburgh, Pa.

The Future for Synthetic Fibers, F. J. Soday, vice president, Chemstrand Corp.

FUTURES IN THE CHEMICAL INDUSTRY—II, G. Rieger, Diamond Alkali Co., Cleveland, O., presiding.

Changes in the Inorganic Chemical Industry and Its Raw Materials, I. H. Munro, vice president, Solvay Process Division (Allied), New York, N. Y.

The future role of large-volume, established inorganics, the employment of rare earths and metals in new developments, the emergence of the heavy metal inorganics as potential sources of energy, are discussed among other important future developments.

The Future for Raw Materials for Organic Chemicals, R. L. Kittle, manager, Manufacturing Operations, Shell Chemical Corp., New York, N. Y.

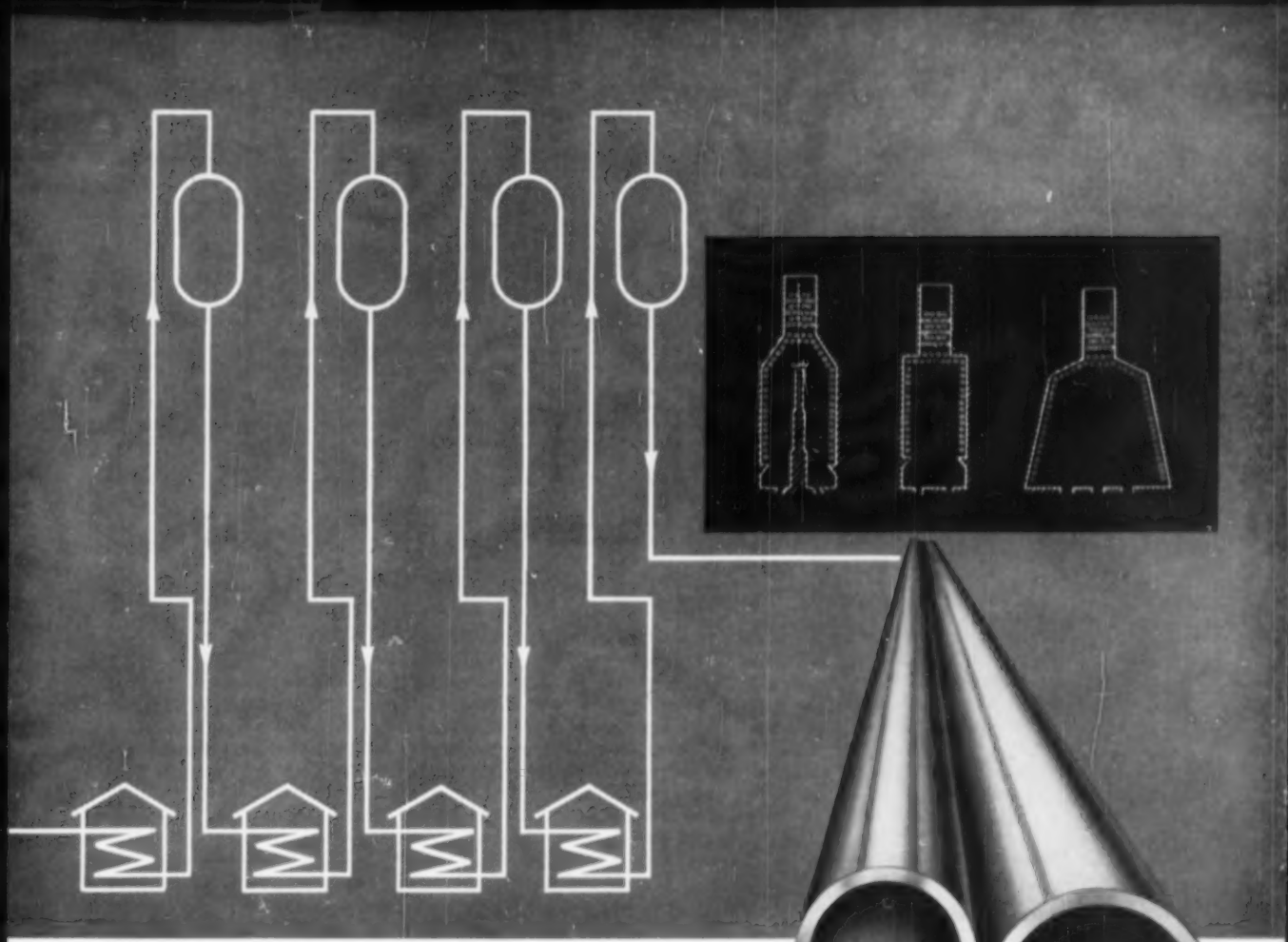
A look into the future of the three basic sources of raw materials for organic chemicals: 1) agricultural products (expected to diminish); 2) coal (not likely to keep up with demand); and 3 petroleum (adequate).

Tomorrow's Chemical Processing, M. J. P. Bogart, The Lummus Co., New York, N. Y.

A discussion of the technological, economic, and social motive forces important to the evolution of chemical process and product as exemplified by: 1) improvements in present techniques; 2) new construction materials; 3) new raw materials; 4) new tools; 5) government influence; 6) energy sources; 7) economic factors.

The Changing Picture In Chemical Selling, A. P. Felton, vice president, Bruce Payne and Associates, Inc., Westport, Conn.

Dynamic changes in our economy have produced equally dynamic changes in chemical selling. Some of the trends that will demand attention by 1965 are: different products, specification buying, changing markets, bulk purchasing, diversification, etc. Security will lie only in mobility.



HOW MANY PROBLEMS IN THIS PICTURE?

Some layouts present a multiplicity of engineering, purchasing, warehousing and financing problems. Conceivably, (1) Return bends have to be designed for a perfect fit on their heater tubes, (2) Both tubing and fittings must meet the same exacting customer standards, (3) Simultaneous delivery must be made to guarantee erection schedules, and (4) Money tied up in material in process at any one time must be kept to a minimum.

In such a situation, it's best to depend upon Mr. Tubes for coordinated delivery of perfectly matched tubing and fittings.

Think of your own requirements in terms of the right tube for the job, tubing (or alloy pipe) and welding fittings and forged steel flanges as components of an integrated system—and you'll make B&W's Mr. Tubes a member of your team. The Babcock & Wilcox Company, Tubular Products Division, Beaver Falls, Pa.

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General description of the program for the Congress and Exposition on page 41. The next (February) issue of CEP will carry the complete, detailed program with list of Exposition exhibitors and floor plan; will also contain selected papers pre-published in advance of the meeting for the convenience of those attending.

AEC CHAIRMAN STRAUSS OFFERS AID—"The 1957 EJC Nuclear Congress in Philadelphia next March may of course rely on the AEC for every available aid," said Mr. Strauss during a recent meeting with Congress officials. Shown (l. to r.) are: E. J. Brunenkant, chief, Industrial Information Branch, AEC; T. A. Marshall, ASME, manager of Congress; J. V. Friel, director of the Exposition, which is part of Congress; Admiral Strauss; Morse Salisbury, AEC information director; A.I.Ch.E. executive secretary Van Antwerpen, representing sponsoring societies; and H. F. Grebe, exhibits manager.

NUCLEAR CONGRESS & EXPOSITION

Philadelphia, March 11-15

The following communications have been received, up to time of going to press, from Fuel Cycle Sessions chairmen, who at the invitation of CEP are supplying explanations of their portions of the program. In the next issue, CEP expects to carry the still-to-be-received communications.

A.I.Ch.E. Fuel Cycle Program, Session I: Uranium and Thorium Production

By F. L. Cuthbert,

National Lead of Ohio

The production of uranium and thorium metals and their compounds is basic to any consideration of the fuel cycle and to our entire nuclear energy program, whether for military or peacetime applications. It is the purpose of this Session to elaborate on some of the aspects of this production of nuclear fuels.

As in most metal industries, the methods used to mine and concentrate the ores vary, dependent upon the location of deposit, type of mineralization, and associated gangue, and per cent of the metal present. Considerable technological progress has been achieved in uranium concentrate production leading to modern ion-exchange and solvent extraction processes. The first paper in this Session describes an example of some of the unusual approaches in pilot plant work to develop a process for concentrating western United States ores.

The present uranium feed materials chain provides for receipt of ores and concentrates, extraction of the uranium as uranyl nitrate, production of uranium dioxide and hydrofluorination of the dioxide to produce uranium tetrafluoride. This material can be used to produce metal or provide a feed for the gaseous diffusion chain to provide uranium of desired isotopic enrichment. Paper number two describes a process of refining uranium concentrates by solvent extraction.

The recovery and utilization of all uranium scrap values is extremely important from both economic and health points of view. Two examples of recovery operations are presented in papers three and four which concern themselves with recovery of uranium scraps from the gaseous diffusion operation and from a residue resulting from the reduction of uranium tetrafluoride to metal operation.

Interest in thorium has lagged in contrast to uranium, owing to many reasons. However, much research and development has been conducted leading to pilot plant or semi-works processes for the production of thorium. Paper number five presents an excellent summarization of present day technology.

A.I.Ch.E. Fuel Cycle Program, Session 2: Fuel Cycle Interrelationships

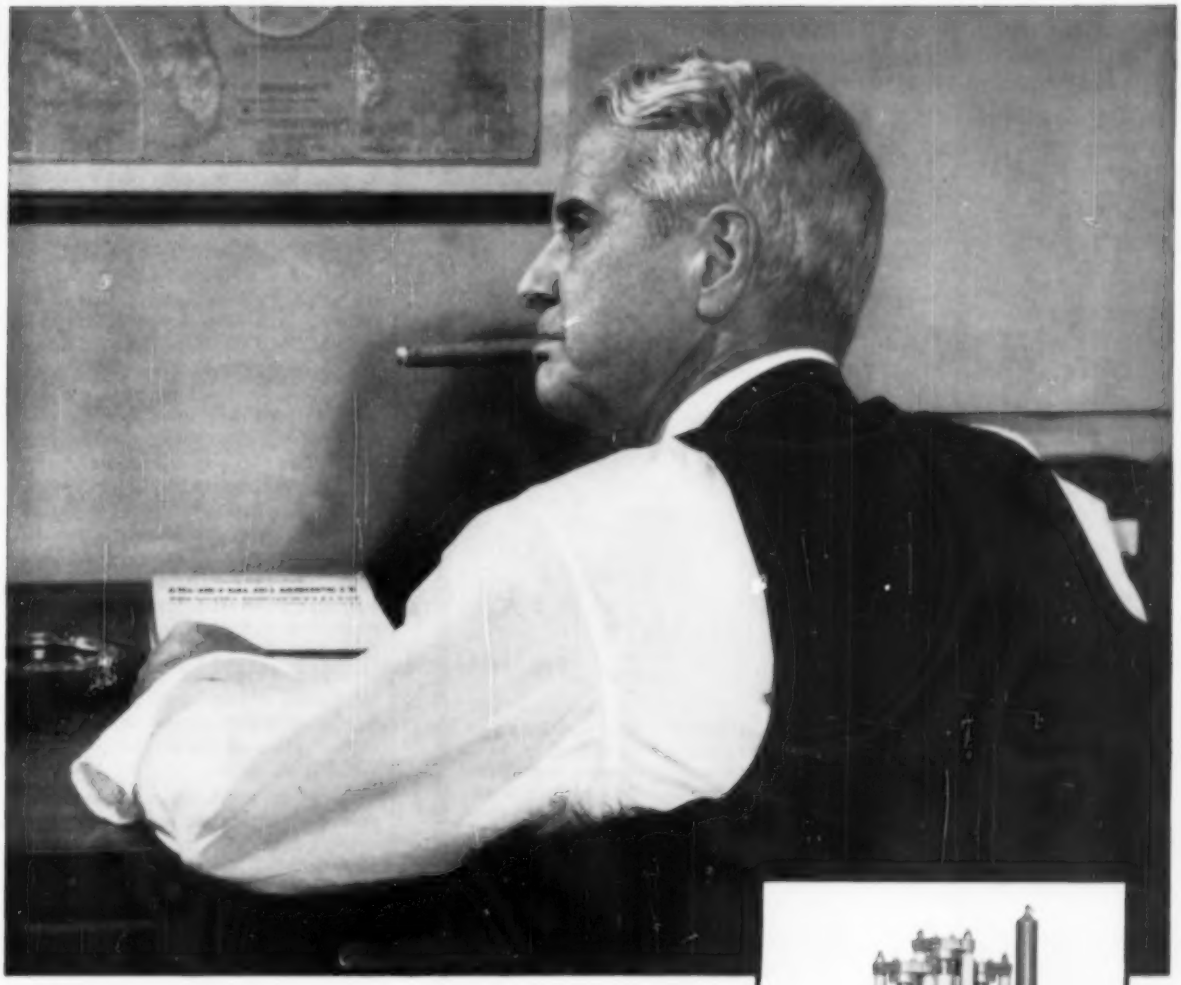
By E. B. Gunyou, Vitro

Nuclear-reactor fuel differs from conventional fuels, such as coal, gas, and oil, in several ways. Probably the most important of these, from both a technical and economic viewpoint, are: (a) its extremely high energy potential per unit weight, (b) a high degree of purity required for efficient use, and (c) the intense radiation thrown out in all directions by its ashes. These characteristics result in a more complex fuel cycle than is enjoyed by the more conventional fuels, and must be taken into account when considering the application of nuclear fuels for generation of useful energy.

The nuclear fuel cycle begins with a conventional pattern of recovery of uranium from mineral deposits. It has to be located, dug out, and separated from the unwanted trash. The recovery of such deposits is not new and unique; even the recovery of uranium oxide and uranium salts was established on a limited scale long before the existence of Q-clearances and AEC-277 forms. It is after the recovery and isolation of the fuel constituent that the fertile imagination of man begins to complicate the fuel-cycle picture.

Just looking at the reactors that have been built or are definitely planned, there is a formidable array of combinations and permutations. The branches of the fuel cycle begin to fan out like a first-year physics model of a chain reaction. We have uranium fuel in the form of metal, oxide, alloys, and salts. We have enrichments of all degrees—depleted, natural, 1.1%, 1.4%, 1.8%, 2.7%, 2.9%, 10%, 20%, 45%, and over 90%. The configurations of fabricated shapes are limited only by the imaginations of the designers and the pocketbooks of their sponsors. There are metal slugs, rods, pins, plates, sheets, foil, and no shape whatever (in aqueous or liquid metal solution). There are metallic alloys and dispersions with zirconium, aluminum, steel, copper, and niobium; there are cermets, ceramics, and plastics. Then, on top of all this, the whole conglomeration is wrapped up in a cladding of steel, aluminum, zirconium, sili-

(*Continued on page 92*)



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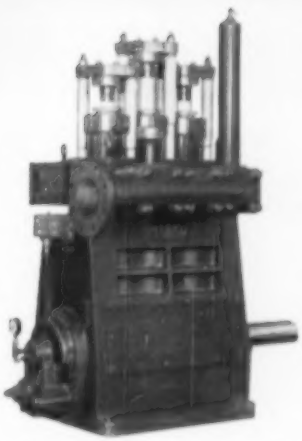

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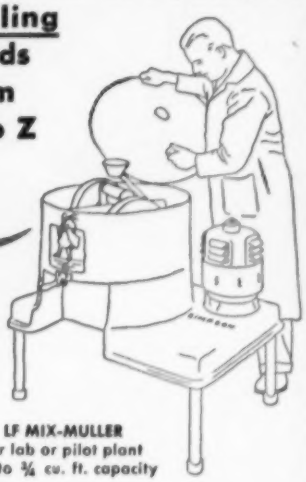

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NUCLEAR CONGRESS

(*Continued from page 90*)

con carbide, or any number of alloys, and placed in a reactor. Long before the fuel is all consumed, it has to be removed from the reactor, the valuable constituents recovered, and the resulting radioactive effluents safely disposed of, and the fuel fabricated for reuse.

The session on *Fuel Cycle Interrelationships* presents the entire fuel cycle in its proper perspective to emphasize the interdependence of each phase. The session is intended as an orientation for the more detailed discussions presented in succeeding sessions on specific phases of the fuel cycle. The first paper provides a general description of various fuel cycles, emphasizing the need for recycle of unburned fissionable material and the problems inherent in this recycle. This is followed by a series of three papers, reviewing the fuel cycle from the standpoint of the reactor designer, the fuel fabricator, and the spent fuel processor. The final presentation of the session will deal with mathematical relationships that should be helpful in consideration of the several phases of nuclear fuel cycles.

As we approach nuclear power generation on a competitive basis, the need is immediately apparent for closer cooperation on all phases of the fuel cycle. The recycle phase can no longer be neglected. No longer can we be satisfied with just making a safe, workable reactor . . . it has to be designed for ease of fabrication and ease of spent fuel handling and recycle. The designer, the fabricator, and the reprocessor have to work closely in this endeavor or all will suffer the consequences in expense and delay. The effectiveness of this cooperation may well be the key to attaining economical nuclear power and to maintaining the United States' lead in the international atomic picture.

A.I.Ch.E. Fuel Cycle Program, Session 5: Spent Fuel Processing—Non-Aqueous

By S. Lawroski, Argonne

This session of the Fuel Cycle is concerned with spent fuel processing by non-aqueous methods. For some time now, non-aqueous processes have been under intensive study to establish their chemical and engineering feasibilities. One compelling reason for the tremendous interest in these methods stems from the fact that they offer

(*Continued on page 98*)

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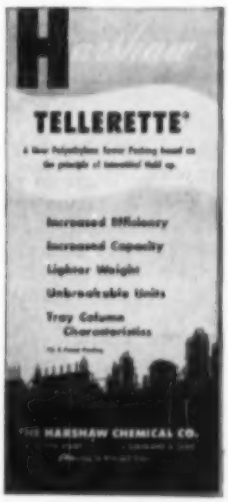

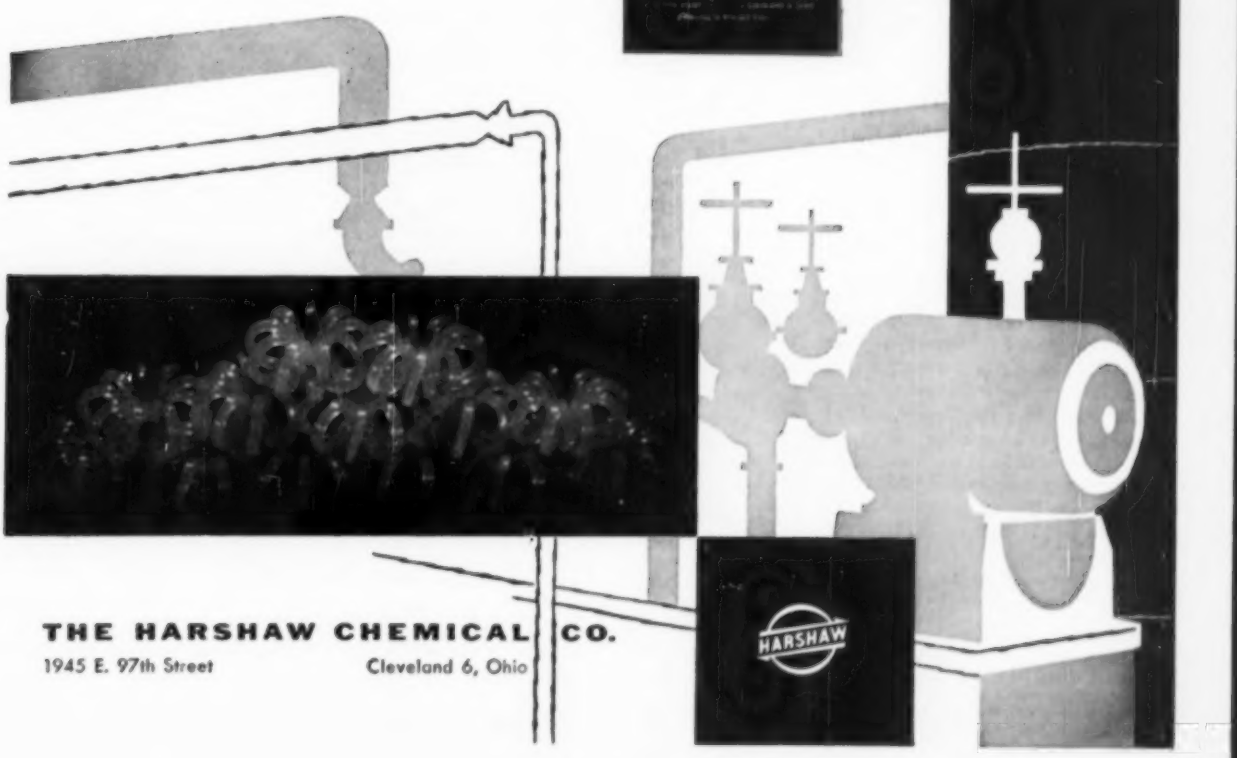

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A Boston Meeting Report

it is difficult, but vital, to find

. . . a performance yardstick for THE CHEMICAL SALES ENGINEER

Basically, the chemical sales engineer is a chemical engineer who fits his company's products to the needs of the buyer. Consensus of recent panel: The sales engineer must be judged and compensated more as an engineer than as a salesman. His work largely precludes quota and commission arrangements common in many sales operations . . . much of his work is creative, done with teams . . . intangibles play large part in his effectiveness, making contribution hard to measure.

How does one tell when chemical sales engineers are doing their job well, and on what basis should they be compensated?

These and other important questions to that part of the chemical engineering profession engaged in sales were debated recently at a panel discussion * led by New York equipment sales executive Jim Costigan, of the Sharples centrifuge firm.

Sales Engineer—Not Salesman

Keynote was sounded by panelist Ehrisman, "The sales engineer is *more* than a salesman." He cannot be judged or compensated in the same manner as a salesman. His work is often long-range, he deals in equipment and services as well as chemicals, and there are many intangibles in his work.

Heavy equipment man Ford emphasized, "the sales engineer cannot be adequately remunerated or motivated by commission payments on the basis of orders obtained." The intangibles, which cannot be realistically compensated, are in many ways the main part of his work. In chemical sales engineering the groundwork and the planning, the knowledge of engineering and the ability to work with the buyer as an engineer rather than a salesman, can reap bigger profits in the long run than a sale itself.

* Chemical Sales Engineering Symposium, Boston Annual Meeting of A.I.Ch.E. J. T. Costigan, N. Y. Dist. Mgr., Sharples Corp., chmn.; J. W. Ogden, manager, Chemical Plant Sales, Foster Wheeler Corp.; T. B. Ford, vice president, Sales, Dorr- Oliver; H. O. Ehrisman, general sales manager, Foxboro; T. E. Stevens, purchasing manager, Equipment and Construction Materials Division, Du Pont.

Non-Monetary Advantages

How do you base the compensation of a sales engineer, then? A key, according to Ford, lies in five non-monetary advantages which work both ways—benefit the man and at the same time benefit the employer. The sales engineer's chance to have these advantages on a good salary is part of his total "pay." On the other hand, the sales engineer's desire to have these advantages is a prime requisite towards being first rate in the work.

Perhaps prime among these advantages is:

1) *The chance to be creative.* Almost inherent in the definition of a sales engineer is his participation—to a greater or lesser degree—in the design, development, and engineering work of his company. It is up to him to understand the customer's engineering needs, and to help the customer get what he wants, and help his company design and produce what is needed. That creativeness should be "more" rather than "less" for a satisfied sales engineer, the panel was agreed.

Perhaps as important to some, however, will be some other of Ford's advantages:

2) *Freedom of movement.* No time clocks, plans own work, few good sales engineers in the "9 to 5" category. But being left on his own may or may not be a blessing to the sales engineer—it takes a strong character.

3) *Variety of activity.* The sales engineer's day is rarely cut-and-dried, limits are almost never rigidly defined. "For the man who is uncomfortable in a new situation and the man who wants to stick within clearly defined limits, sales engineering may not be advisable. Conversely, for the man who thrives on variety and challenge there is great appeal." (Ford)

4) *Status.* The sales engineer usually becomes an expert in one particular area, which gives him considerable status. As Ford said, "Over a period of time our sales engineers generally become specialists in one field or another—recognized as such inside the company and usually accepted as such by our customers and the engineering field at large." Sales engineering is also a path to top management. "In our company (Ford's Dorr-Oliver) it may or may not be significant that the president of the company and four of the five vice presidents moved into their positions after spending years in sales engineering . . . the prospect of advancement up the ladder of administrative and executive opportunity is a real factor in holding and rewarding the sales engineer."

5) *Worthwhile contacts and friendships.* The sales engineer is basically an engineer who likes people (if he doesn't he had best stick to straight engineering) and one of the most important intangibles is the meeting of friends and associates.

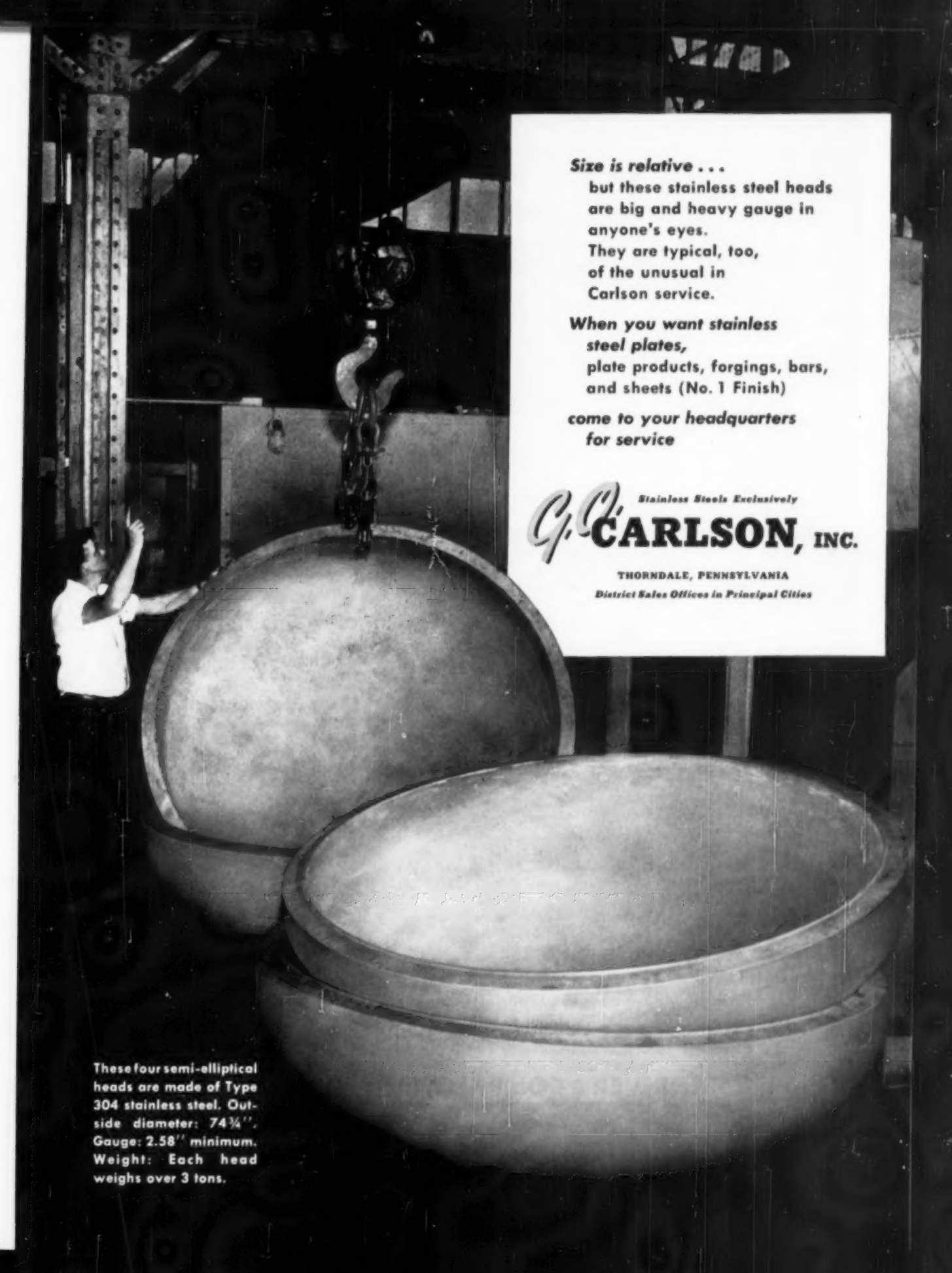
Design-Construction Sales Engineering

A special case of sales engineering that proves the rule by considering the extreme case is the selling of plants and engineering services. The essential fact here, according to Ogden (who is the driving force behind Foster Wheeler's chemical plant contract sales), is that such sales are never a one-man job but a team operation.

In this type of sales engineering, the service sold is so large, complex and competitive—and is often so expensive even to bid on—that it requires not only the sales engineer's efforts, but "the combined talents and efforts of the company's engineers, draftsmen, executives, etc., and one can not be sure who actually accomplished the sale." (Ogden)

Here, the direct measurement of just

(*Continued on page 96*)



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THE CHEMICAL SALES ENGINEER

(Continued from page 94)

how much a given sales engineer contributed to the acceptance of a bid is all but impossible. (It is sometimes the case that the sales engineer's contribution could be "the graceful turning down of an offer for his company to bid on a specific job.") Such a sales engineer, according to Ogden, must be able to judge whether or not his company can do the job, and whether it will pay them to do so—if for even such "fringe" benefit reasons as gaining experience or simple goodwill (which takes selling "in reverse"—selling his own firm on taking the job). He must, in addition, be capable of sitting in the client's offices and elaborating and negotiating on any of the details worked out by his firm's experts at any and all stages of the job.

Ogden terms the sales engineer in this field, "the quarterback of the team effort. If the team is not functioning well, blame the sales engineer. If it is going good, give him the credit."

More Units, Fewer Intangibles

Ehrisman, whose team sells process control instruments, emphasized that yardsticks and quotas *can* be set-up in the selling of the smaller equipment items and industrial chemicals. In these cases there are quotas, but they must be realistic. For example, Ehrisman pointed out, customer companies differ widely in size, type of operation, stage of growth, etc.; size of a territory and travel conditions within it vary greatly; "How many of the sales engineer's new prospects are already well-developed, established users of his own company's products, and how many have essentially standardized on products of competitive manufacture? This is clearly one of the foremost considerations." (Ehrisman.)

The preeminent task in the nurturing of good sales engineers in this field is the setting of realistic quotas, or "par for the course." And the wise supervisor in chemical engineering sales is going to travel a lot with his sales engineers to help them and to get an accurate idea of the performance possibilities in relation to opportunity.

Bivalent Sales Engineer

The good sales engineer, Du Pont purchasing agent Stevens admonished, should remember he is working for two companies at all times—any sales engineer "who does not represent his company to the buyer, and the buyer

(Continued on page 98)

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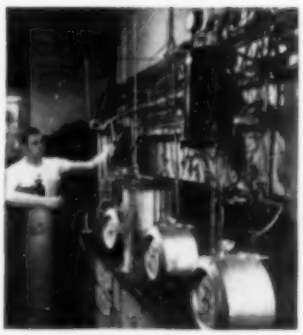

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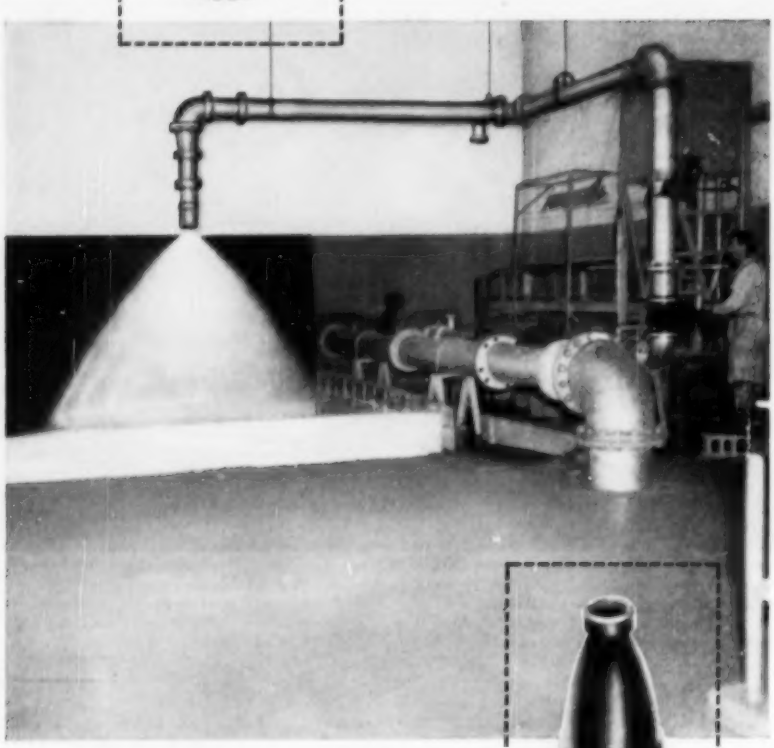

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THE CHEMICAL SALES ENGINEER

(Continued from page 96)

to his company, has failed." Ogden added to this point by citing the sales engineer's watchword *how can I help my customer's company?*

While the panel agreed that in practice sales engineering is a good road to top management, Ford sounded the warning that management should not be offered as a goal towards which all first rate sales engineers should strive. Just being a good sales engineer is as valuable as being a good vice president. In Dorr-Oliver, Ford emphasized, it is not uncommon for a senior sales engineer to be paid more than his division manager.

NUCLEAR CONGRESS

(Continued from page 92)

promise of substantially reducing the number of operating steps normally required in the reactor fuel cycle. An outstanding example of this can be cited in the use of certain pyrometallurgical processes in which the purification of irradiated reactor material is achieved while retaining the metallic state. Hence, the product is immediately ready for refabrication. Another important advantage of this class of reprocessing methods is that these methods are much less susceptible to radiation effects than are other methods, such as solvent extraction schemes using organic solvents. This means that shorter cooling periods and higher concentrations of irradiated materials can be readily accommodated. Consequently, there is permitted substantial reduction of inventories of these materials, and there is also an improved prospect for obtaining the fission products in highly concentrated form for more economic utilization or storage of these by-products. The compactness of these methods is obvious. Mention should also be made of the fact that some of these nonaqueous methods can purify the fuel without losing certain expensive alloying metals often added to improve fuel performance characteristics.

Therefore, notwithstanding some of the very serious problems posed in the application of most of the nonaqueous processing methods, e.g., operating at 1,200° C. or above and handling of corrosive salts, there is a very great incentive for the successful development of these methods. Since reprocessing costs by present standards must be very substantially trimmed in

(Continued on page 100)

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NUCLEAR CONGRESS

(Continued from page 98)

order to achieve economic nuclear power in this country, it is very possible that it will be mandatory to employ some type of the processing methods described in this session.

One of the papers presents the progress thus far made on a non-aqueous process for purifying irradiated uranium by fractional distillation of fluorides. Pilot plant results indicate this method to be capable of excellent decontamination and recovery of uranium from irradiated fuel. The caliber of process performance obtained shows this purification method to be a real competitor for present methods of reprocessing irradiated uranium fuels, especially the highly enriched types.

Another paper discusses recent results obtained with the use of molten mixed halides for continuous purification of a liquid metal fuel. This investigation, like that represented by the work described in the last three papers, illustrates the determined effort now being made by many groups to select and integrate intimately the reprocessing operation with other steps of the fuel cycle.

The remaining three papers deal with the study of processes and concepts of plant design wherein pyrometallurgical processing methods are employed. Techniques and experimental data are presented for the use of molten magnesium to separate plutonium from uranium. This depicts an extremely direct approach to the problem of processing irradiated uranium blanket material for the purpose of concentrating the contained plutonium to strengths suitable for replenishment of reactor cores fueled with plutonium. Conceptual designs with estimates of costs are given for an oxide slagging process (more correctly, a melt and dross refining process). Since this type of process results in only partial removal of fission products, remote fabrication is necessary for re-use of the purified metal. A conceptual design for this type of fabrication plant is presented in one of the session papers. It is very appropriate that the subject of a remote-type fabrication plant has been included in these papers because the use of this type of plant may ultimately be necessary, regardless of the type or decontamination performance of the reprocessing method used. This situation can occur in the recycling of fuel due to the production of highly radioactive heavy isotopes through capture reactions.

WHITE SULPHUR PROGRAM

(*Continued from page 85*)

In the Computers in Chemical Company Control session, two complete computer systems are described (Monsanto, Diamond Alkali). How the engineer can make his own cost estimations on computers, estimate changes in costs with changes in process details without actually changing the process will be brought out.

After Business Hours

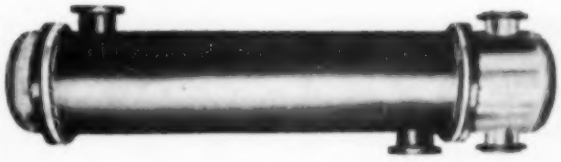
Sunday afternoon "Get Acquainted" sessions have become so much a custom at National Institute meetings that no program committee would dare omit one. The Central Virginia Section, in conformity with custom and with trepidation about breaking this popular precedent, will marshall the regal and lavish facilities of the Greenbrier Hotel to welcome early arrivals with the accepted fanfare and refreshments.

On Monday night a banquet will precede dancing in the famed Old White Club. The guest speaker at this banquet will be Hugh L. Rusch of the Opinion Research Corporation of Princeton, New Jersey.

Tuesday night's presentation of "The Rainmaker" by Virginia's famous Barter Theater will be a rare treat indeed for Institute members. "The Rainmaker" was conceived by N. Richard Nash after a trip to the drought-ridden Southwest during the Summer of 1950. It appeared in play form for the first time in 1951, although its first performance did not take place until the Summer of 1953 when it was presented in abbreviated form as a television play.

Routes to the Greenbrier

The Greenbrier is accessible by train or car if you prefer the land route, but it can also be reached directly by plane. If you fly your own plane, or have the Company plane at your disposal, you can use the Greenbrier Airport, a CAA Class 2 field, only one mile from the Hotel. There you will find a 3,500 foot concrete runway and full servicing and starting facilities for all but the largest aircraft. Charter service from many of the large terminals ringing White Sulphur (e.g., Washington, Pittsburgh, Charleston, W. Virginia, Roanoke, Virginia) can be arranged by contacting the Greenbrier Airport at White Sulphur Springs directly. Day flights only can be arranged and reservations are necessary for this non-scheduled air-taxi service.



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NEW ESTIMATES ON PARAXYLENE PRODUCTION FACILITIES ANNOUNCED BY BADGER

Based on plant studies, new data on process flow rates, product yields, operating requirements and capital costs are estimated for two and three stage fractional crystallization plants with a capacity of 15 million pounds per year of paraxylene.

Rapid growth of the polyester fiber industry and the resulting increased demand for high purity paraxylene has encouraged many petroleum refiners to investigate the possibilities of separating the para isomer from their mixed xylene stocks.

The paraxylene separation process entails two or three stages of low temperature crystallization of the paraxylene from a mixture of xylenes and aromatic hydrocarbons. Low temperature chilling is followed by separation of the crystals by centrifuging.

The complexity of the crystallization mechanism is such that the rates of nucleation, diffusion and crystal growth are influenced by the concentration of the paraxylene, the impurities present, the degree of supersaturation, and the nature of the mother liquor. All of these factors are controllable, but the choice of equipment and the process flow employed are of primary importance in the proper control of these mechanisms to attain the maximum yield and purity.

Plant Results

The data presented here are based on plant investigations carried out by

(*Continued on page* 106)

Table 1.—Process Flow Rates and Paraxylene Concentrations

	Two Stage Operation		Three Stage Operation	
Eutectic Temp. of Feed, ° F.	−91.0	−91.0	−91.0	−91.0
Product Purity, wt. %	98.5	98.5	98.5	99.0
Product, lbs./hr.	1,710	1,710	1,710	1,710
Feed, lbs./hr.	10,560	10,560	10,560	10,620
Paraxylene in Feed, wt. %	21.0	21.0	21.0	21.0
Centrifuge Dryness, wt. % Solids				
First Stage	85	80	80	85
Second Stage	93	93	93	93
Third Stage	.....	.....	93	93
Recycle Flow Rate, lbs./hr.				
To First Stage Crystallizer	2,960	11,390	710	480
To Second Stage Crystallizer	.....	.....	270	550

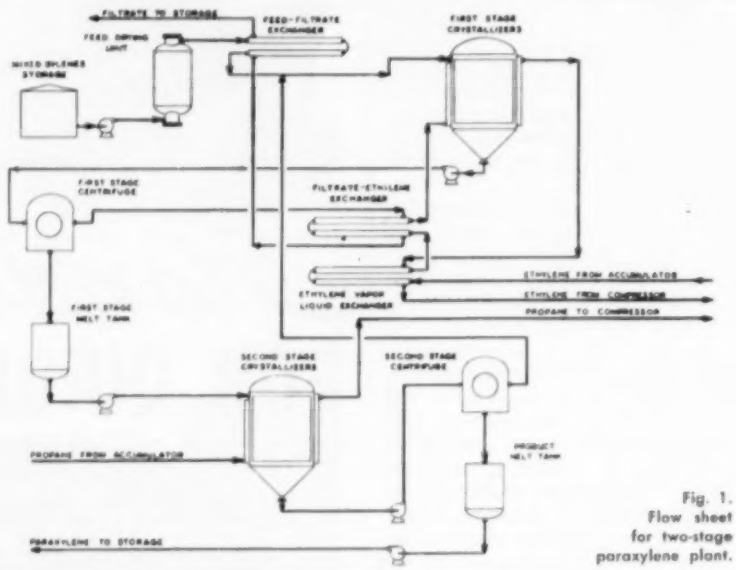

Fig. 1. Flow sheet for two-stage paraxylene plant.

GAS DISCHARGE PROCESS PROMISES COMMERCIAL HYDRAZINE FROM AMMONIA

Recently patented by Lord Manufacturing, new process also said to offer advantages in production of other high-energy fuels and high-temperature resistant polymers.

A new technique, object of a research and development program extending back to 1944, is announced by Lord Manufacturing Co. The process involves the activation, formation and subsequent removal of the product in zones of controlled, inter-related pressure, temperature, and residence time as the reactant material flows through a radio frequency field of decreasing intensity. According to the Lord research staff, gas discharge techniques are particularly applicable to syntheses requiring high activation energy at relatively low temperatures and to those which are difficult or impossible to carry out by conventional chemical means.

At relatively low pressure and temperature a gas under the influence of an electrical field will break down into ions, free radicals and activated molecules. Some of the activated materials will recombine to form products different from the original gas. The nature of the products formed is influenced by pressure, field strength, residence time, reactor surface material and area, temperature, and discharge gap distance. The process has been studied in a range of pressure from 10 to 150 millimeters of mercury absolute, ambient gas temperatures from −73° C. to 100° C., and gas flow velocities from zero to supersonic speeds.

Conversion Efficiency of 2% Claimed

Under semi-pilot plant conditions, the process is said to have produced hydrazine from ammonia at a conversion efficiency of nearly 2 per cent by weight.

Although power efficiency is at present low, it is felt that it can be sufficiently improved so that the process will be "more than competitive with existing methods."

Other Potential Uses

Besides the possibility of producing other high-energy fuels and high-temperature resistant polymers, the process is believed to offer a powerful research tool for the production of rare compounds of exceptional purity. Such products might include: sub-halides of boron and phosphorus; high oxidation states of nitrogen and sulfur; polymeric phosphorus nitrides, halides and sulfides; carbon sub-oxides; carbon fluorine compounds; high-purity tagged compounds; trapped free radicals; and activated complexes.

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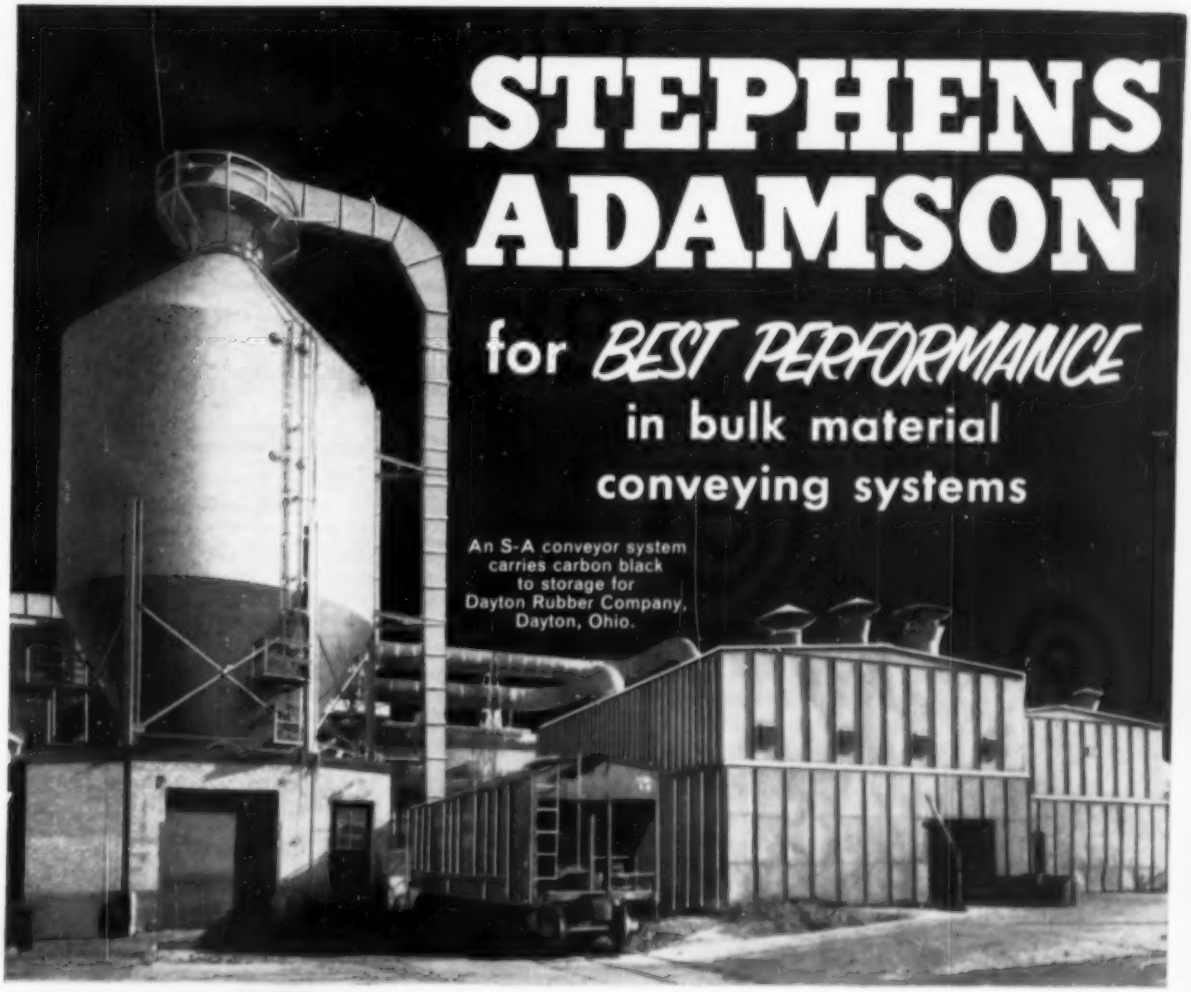

An S-A conveyor system carries carbon black to storage for Dayton Rubber Company, Dayton, Ohio.

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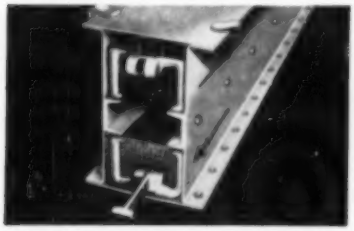

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RETIRED ENGINEERS, SCIENTISTS TO FILL SCIENCE EDUCATION NEEDS IN NEW YORK CITY HIGH SCHOOLS

Short some 47 science teachers in its high schools (6% of total), the New York City Board of Education, under Supt. of Schools William Jansen, has initiated a program of part-time, temporary teaching by retired engineers and scientists.

In what could be a precedent-setting method of alleviating the critical shortage of high school science and mathematics teachers in many parts of the country, New York City is now going ahead with its program to employ civic-minded retired engineers and scientists as teachers. (*CEP*, in the August 1956 editorial, announced that such a move was under consideration, asked for volunteers to make themselves known.)

The 30 people (half of them engineers) who are willing to come from retirement, forfeit their social security payments, and take up the arduous but much-needed task of high school teaching, could be ready to assume classes by February.

The Program

Having secured the 30 volunteers, and with Jansen and the New York State Board of Education now in complete agreement (a major hurdle was State Board's education training requirements which have been cleared away), the program now shapes up like this:

The city will employ the retired people, who have college degrees and good science-math backgrounds achieved during their active careers, on not-less-than a half-time basis at starting salaries of $4-5,000/year, with increases the second year.

The prospective teachers will have to take some form of examination to ascertain their abilities—possibly only an interview examination—and will be given orientation courses in teaching methods. After passing the examination and being oriented, the part-time teachers will be assigned to their classes in the various New York High Schools.

If the program works as well as Jansen, C. F. Pertsch, associate superintendent in charge of the High School Division, and S. Schenberg, supervisor of science, expect, then the city hopes to expand the program in the future, possibly find enough such teachers to achieve a long planned science education expansion in New York which has been blocked by lack of teachers.

The Scientists and Engineers

In Jansen's opinion, most of the retired scientists and engineers will do very well with some teaching training. Although details are not available, the majority of the volunteers are men from industry who have come from retirement in answer to the pressing need of science education today.

These unselfish people, in Jansen's view, are to be congratulated for the far from simple step of leaving retirement and social security benefits to undertake the difficult job of teaching for salaries probably far less than they have been accustomed to.

They are not people who like to do nothing, who like to sit by and watch when they can be of service. Their sense of public service, through which they can play an important part and make a major contribution to the nation, could well be emulated by other well-trained engineers and scientists.

The Implications

While the New York City officials do not consider the program a permanent solution, they do estimate a period of 5 to 6 years at least. The only permanent solution is to have more full-time, trained science teachers, but in the meantime New York State is studying the city program carefully, is considering introducing it elsewhere in the state, and other parts of the country are watching with equal interest.

If the program works well in New York City, Jansen is sure it will be tried elsewhere, particularly in the smaller communities which often have a larger proportion of retired people. Today, many small high schools are not teaching any science at all. They have no teachers. Under a program such as New York City's, it is highly possible that the smaller communities could benefit to an even greater extent with well qualified men right in their own areas.

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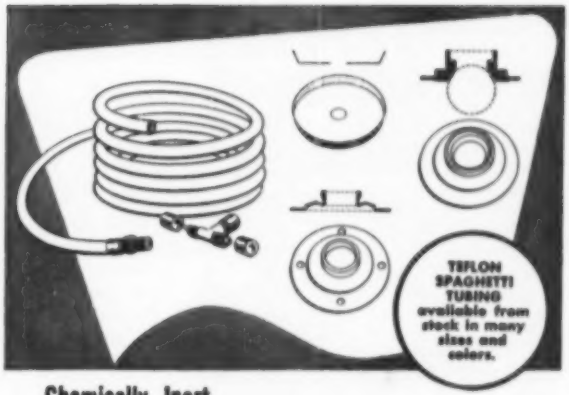

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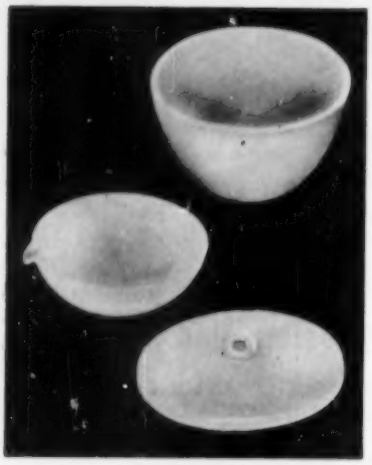

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PARAXYLENE

(*Continued from page 102*)

the Badger Manufacturing Co., as reported in a communication from R. M. Stewart of Badger.

Figure 1 shows a typical flow sheet for a two stage low-temperature crystallization process. Choice of a two or a three stage process is largely dependent on the desired product purity (can be as high as 98%) and on the dryness (to 93% solids) which may be attained on the centrifuges in each stage.

Table 1 lists the various estimated recycle rates and paraxylene purities for a two stage and for a three stage process. Flow rates are shown based on a production rate of approximately 15 million pounds per year of paraxylene from a mixed xylene feed stock containing 21 wt.% paraxylene. It may be seen that at constant product rate and purity the recycle rate is inversely proportional to the centrifuge dryness for both cases. It is also evident that at constant centrifuge dryness the recycle rate is appreciably lowered by the addition of another stage of crystallization.

Investment

Both capital investment and operating utilities for a paraxylene recovery plant are affected by the analysis of the plant feed stock. Mixed xylene feeds of lower paraxylene concentrations and lower eutectic temperatures require larger refrigeration loads and consequent increased capital investments and utilities.

Estimated utilities for both a two stage and a three stage process are given in Table 2.

Table 2.—Approximate Plant Utilities for 15 MM lbs./yr. Paraxylene Product

	Two Stage Process	Three Stage Process
Electric Power, kw.	520	575
Cooling Water, gal./min.	525	600
Steam, lbs./hr.	875	1,100

Capital investment for a plant to produce 15 million pounds per year of 98.5 wt.% paraxylene from a feed stock of average composition is estimated at $1,250,000 for a two stage process and $1,650,000 for a three stage process.

First commercial fermentation production of lysine, one of the eight amino acids considered essential to human nutrition, is now in operation at Chas. Pfizer & Co. □

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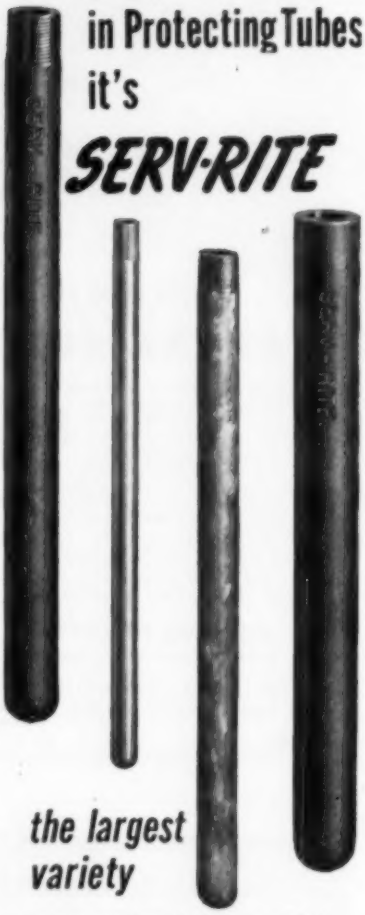

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Television is being used for the first time by Esso Research and Engineering Company in pilot plant operations at its Bayway, N. J., facilities. The closed circuit set-up permits shift foremen to check the safety of operators in a pilot plant unit 300 feet away in a separate building. In case of trouble the foreman would know immediately and could take quick measures. Another receiver is installed in the shift inspector's office.

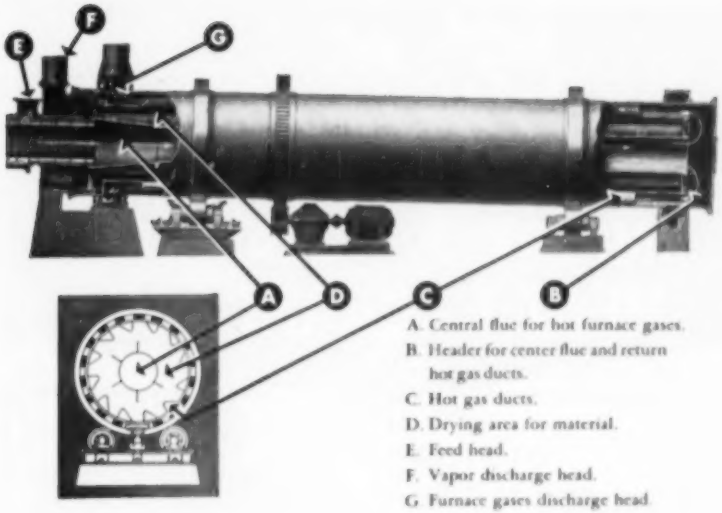
Union Carbide Research Institute to engage in basic scientific research will be located near Tarrytown, N. Y. Major purpose of the new Institute will be to contribute to fundamental knowledge of the physical and chemical behavior of matter under ordinary and extreme conditions of pressure and temperature. □

The National Bureau of Standards has developed a non-destructive procedure for ascertaining both the size and position of pores and other flaws which seriously impair the quality of industrial electroplated coatings. The method involves photographing an electroplated specimen exposed to radiation. Details in National Bureau of Standards Technical Report 2057. □

New land and buildings in Des Plaines, Ill., will become the location of Celotex Corp.'s main center of research. The company intends to broaden and intensify its program of scientific research and development. □

A patent on the new antibiotic, cycloserine, and a method for making it by fermentation techniques, has been granted to Chas. Pfizer & Co. Pfizer will announce its marketing plans for cycloserine shortly. □

A thin, protective aluminum "skin" only two and a half mils thick has been placed on copper wire by Westinghouse Electric engineers. The "skin" promises to increase the life, reduce the size, and raise the efficiency of present-day electrical equipment by allowing it to operate over long periods of time at higher temperatures than are now practical. □



A. Central flue for hot furnace gases.
B. Header for center flue and return hot gas ducts.
C. Hot gas ducts.
D. Drying area for material.
E. Feed head.
F. Vapor discharge head.
G. Furnace gases discharge head.

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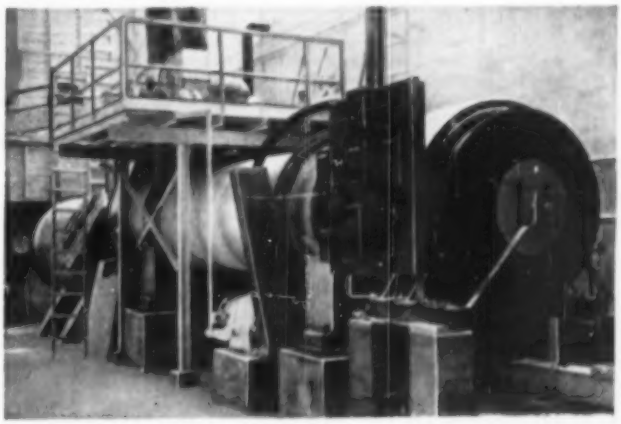

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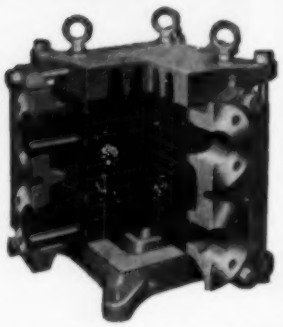

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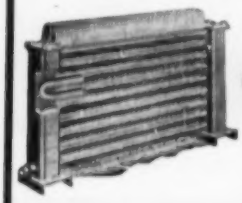

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RESEARCH NEWS

A reactor physics division has been established at Battelle Institute, Columbus, O., to coordinate the increased volume of reactor research now under way at the Institute. □

Arthur D. Little, Inc., has expanded its activities into the high temperature field and is completing a solar furnace for such research. Little has long been engaged in extreme low temperature research, now will also be working with temperatures of 3500° F. The solar furnace being developed will be of a significantly different design, will be completed soon, will serve as model for others to be offered to other research labs. □

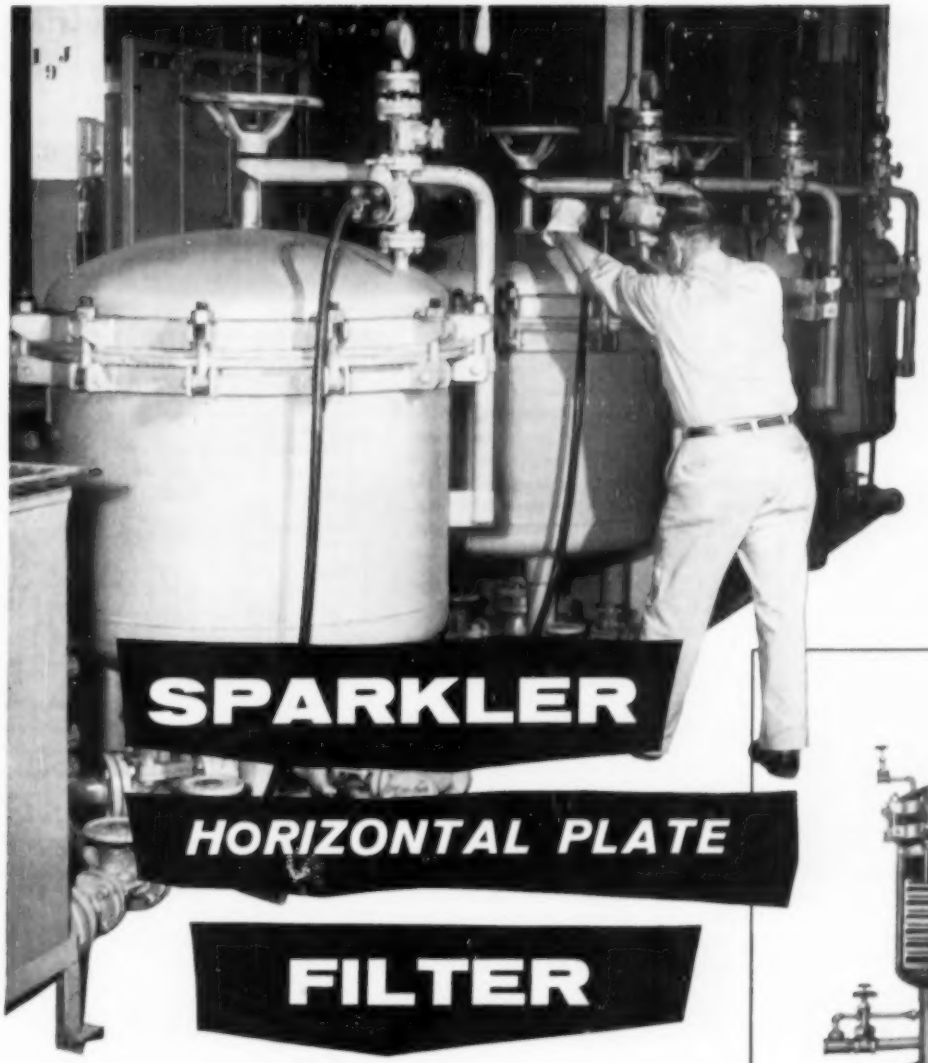
Research studies on the development of high energy chemical fuels will be capsuled from years into weeks by use of a new IBM computer installed at the Niagara Falls laboratories of the Aviation Division of Olin Mathieson Chemical Corp. The new electronic computer, known as the IBM 650, will be used to calculate chemical equilibrium constants, reaction temperatures, enthalpy and entropy, and other factors important in the high energy field. Information will be used at Olin Mathieson's new $36 million high energy fuels plant at Model City, N. Y. □

A highly accurate spectrographic method for determination of metallic impurities in powdered zirconium pyrotechnic compositions has been developed for the Army. A report of the research is available for industry use through the Office of Technical Services, U. S. Dept. of Commerce. □

The new $4 million Research Center of United States Rubber Co. at Preakness, N. J., will be the company's headquarters for research in the fields of rubber, plastics, textiles and chemicals. The company expects to dedicate the lab in the fall of this year. □

Development of a new latex binder has been announced by Monsanto. The material is reported to have good weather resistance and the ability to form a strong, durable film quickly, even at near-freezing temperatures. □

A contract for the study and design of a small source of heat utilizing the decay energy of reactor produced isotopes or reactor fission products has been awarded by AEC to the Nuclear Division of the Martin Company, Baltimore. □



SPARKLER horizontal plate FILTERS

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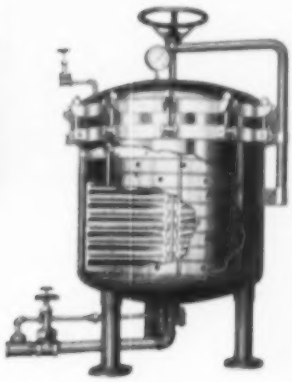

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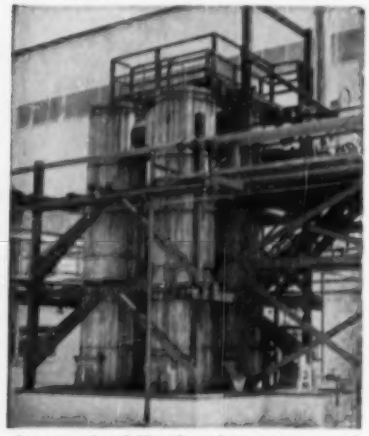

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INSTITUTIONAL NEWS

Awards, ranging from $3,600 to $5,000, for postdoctoral study in statistics have been announced by the Committee on Statistics of the Univ. of Chicago. The awards are intended for persons "whose primary field is not statistics but one of the physical, biological, or social sciences." Closing date for application for the academic year 1957-8 is Feb. 15, 1957. □

The "Outstanding Activities" award of the American Society of Association Executives was won in 1956 by the Manufacturing Chemists Association, Inc. The presentation was in recognition of the importance of the safety program which the MCA conducts on behalf of the chemical industry. The award was announced recently in New York. □

Revised or amended standards treating the storage, handling, and use of liquefied petroleum gas have just been published by the National Fire Protection Association. The standards, four in number, are available in pamphlet form from the NFPA, 60 Batterymarch St., Boston, and are included in the 1956 edition of the National Fire Code. □

Shell Merit Fellowships, which were awarded to 60 high school teachers in 1956, will be received by a significantly greater number of teachers in the summer of 1957. This was announced recently by M. E. Spaght of Shell, president of the Foundation, who said that the exact number would be decided at a directors' meeting this fall.

Recipients of the Shell Fellowships in 1956 received allowances for travel costs to Stanford or Cornell, tuition fees, living expenses and $500 in cash to offset loss of potential summer earnings.

Mathematics, physics or chemistry teachers with five years' experience and known leadership ability will be eligible for the fellowships. □

Cultural studies are to be emphasized this year at N. Y. Univ. College of Engineering. The plan, based on a two-year study, was recently announced by Dean Thorndike Saville, who states that the projected additional courses are designed to give the graduate engineer as adequate a grasp as possible of his Western heritage and a vivid sense of the increasingly important role of his profession in perpetuating and developing this invaluable legacy. □

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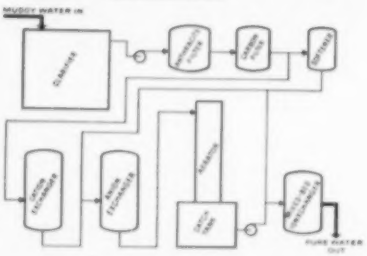

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America's leading companies have been asked to nominate their most promising young executives for Sloan Fellowships for study in the MIT School of Industrial Management this year. As recipients of Sloan Fellowships, those selected will attend the 20th Executive Development Program which begins in June at MIT. In a full year at the school, the fellows will study in depth the fundamentals that underlie sound management action. □

In a joint statement, the three major U. S. lithium producing companies (American Potash and Chemical, Foote Mineral, and Lithium Corp. of America) have announced that the American Lithium Institute, Inc., has been established for the purpose of conducting research on lithium and its compounds. The Institute has been formed to meet the growing necessity for a central organization staffed to direct research on problems of an industry-wide nature. It will maintain offices in Princeton, N. J. □

A symposium dealing with research techniques useful in investigating the molecular structures of petroleum stocks boiling above 600° F. will be held Feb. 8 and 9 at the Jung Hotel in New Orleans under the sponsorship of Research Division IV on Hydrocarbon Analysis of ASTM (American Society for Testing Materials) Committee D-2. Fifteen papers will be delivered: nine by men from American oil companies, 1 from Great Britain, one from a paper company which is a heavy consumer of petroleum products, and two by Carnegie Tech faculty members. □

General Dynamics Corp. has made a grant of $1 million to the University of California to assist in the expansion of the La Jolla campus to provide for a graduate program in science and technology. □

This year's Corrosion Control Short Course of the College of Engineering, Univ. of Oklahoma, will be held on April 2, 3 and 4. □

The United States World Trade Fair will be held in the New York Coliseum April 14-27. A total of over 40 nations are expected to display their resources and products in 3,000 exhibits at what President Eisenhower has called another step in improving political and economic conditions throughout the world. □

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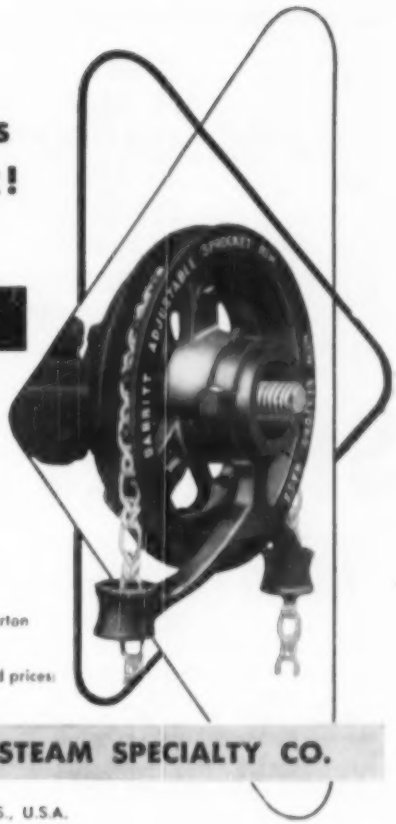

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DID YOU KNOW AN A.I.Ch.E. FOUNDER?

Forty chemical engineers were Charter Members of the Institute in 1908. Now Secretary Van Antwerpen is preparing a *History of the A.I.Ch.E.*, wants to honor all charter members. But they are elusive—Do you have any information?

The year 1958 will be the 50th Anniversary of the founding of A.I.Ch.E. As part of the commemorative year's activities, several special books are being published:

Chemical Engineering Around The World, under the guiding hand of Professor Edward Piret; *Chemical Engineering in the Process Industries*, Volume I being handled by W. Dixon, Atlantic Refining, and Volume II in the hands of A. W. Fisher, Arthur D. Little; a series of commemorative volumes on modern chemical engineering based on the symposia for the 50th Annual Meeting; *History of the American Institute of Chemical Engineers*, being put together by F. J. Van Antwerpen, secretary of the Institute.

The Elusive Forty

It is for the latter volume that secretary Van Antwerpen is appealing for information on the 40 founding members. He wants to know all about them—where they worked, what they did, where they are now, their achievements, honors, scientific progress, anecdotes!

The names of the founding forty are listed below. Wives, sons, other relatives, friends, business associates, former students and employers please communicate with F. J. Van Antwerpen, American Institute of Chemical Engineers, 25 W. 45th Street, New York.

Edward G. Acheson
George P. Adamson
*Jerome Alexander
Lucius E. Allen
*G. E. Barton
William H. Bassett
A. Bement
William Miller Booth
H. F. Brown
J. M. Camp
Charles A. Catlin
Frederick Dannerth
Allan W. Dow
F. W. Frerichs
Wm. M. Grosvenor
Edward Gudeman
Eugene Haanel
George H. Heath
Herbert Hollick
David Wilbur Horn
Henry A. Hunicke
Walter R. Ingalls
H. M. Kaufman
Arthur C. Langmuir
Wm. P. Mason
Chas. F. McKenna
Richard K. Meade
A. L. Miller
Louis A. Olney
John C. Olsen
Charles Lee Reese
Henry S. Renaud
Ludwig Reuter
Andrew Robertson
Samuel P. Sadtler
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David Wesson
J. Edward Whitfield
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Approximately 4,500 high school, and 250 college, teachers of science and mathematics will benefit during the summer of 1957 from teacher-training programs sponsored by the National Science Foundation at summer institutes in 95 colleges and universities. □

Three buildings valued at $250,000 have been deeded to the Gaston (North Carolina) Technical Institute by the Firestone Tire & Rubber Co. The transaction took place at Firestone's Gastonia, N. C., textile plant. Gaston Technical Institute plans to sell its present facilities and move into the new quarters. The Institute is operated by the Univ. of North Carolina. □

Seven national awards in engineering education will be given by the American Society for Engineering Education at its 1957 Annual Meeting at Cornell University, June 17-21. Competition for the awards is now open, nomination blanks are ready.

The seven awards are:

1) The Lamme Award—to an engineering educator for distinguished achievements toward the advancement of the profession.

2) The George Westinghouse Award—an annual $1,000 prize for distinguished contributions to teaching engineering students.

3) The Vincent Bendix Award—for top achievement in engineering research in colleges and universities.

4) The Curtis W. McGraw Research Award—to honor young staff members for contributions through engineering college research—a $1,000 prize.

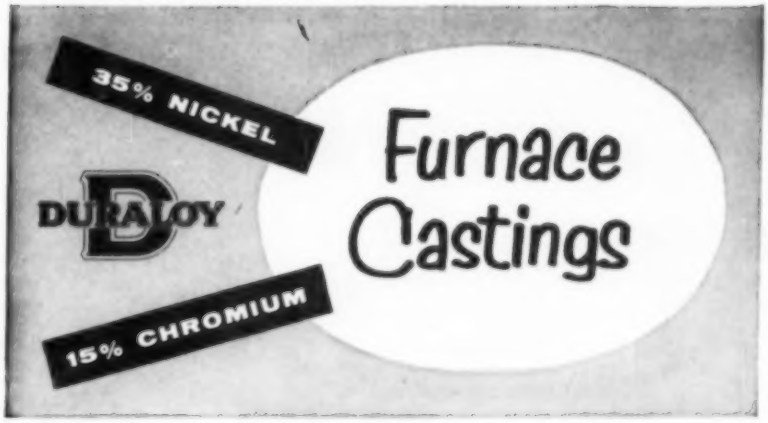
5) The James H. McGraw Award—an annual prize of $500 for established achievement in technical institute education.

6) The President's Award to Young Engineering Teachers, given annually for papers written by young engineering teachers on a phase of engineering education.

7) The Engineering Drawing Award.

Further information and blanks for nominations are available from W. Leighton Collins, Secretary of ASEE, University of Illinois, Urbana, Ill. □

The Tenth Western Metal Exposition will be held concurrently with the Tenth Western Metal Congress, March 25-29 in Los Angeles. Held under the auspices of the American Society for Metals, the Exposition will occupy the entire Pan-Pacific Auditorium and three canvas pavilions. □



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CANDIDATES FOR MEMBERSHIP IN A. I. Ch. E.

The following is a list of candidates for the designated grades of membership in A.I.Ch.E. recommended for election by the Committee on Admissions.

These names are listed in accordance with Article III, Section 8 of the Constitution of A.I.Ch.E.

Objections to the election of any of these candidates from Members and Associate Members will receive careful consideration if received before February 15, 1957, at the office of the Secretary, A.I.Ch.E., 25 West 45th Street, New York 36, N. Y.

Member

Adams, Marvin A., *St. Paul, Minn.*
Anderson, James A., Jr., *Baytown, Texas.*
Boon, Joe G., *Charleston, W. Va.*
Campbell, Delwin M., Jr., *St. Louis, Mo.*
Campbell, Ramsey G., *Berkeley, Calif.*
Carney, Charles H., *Baytown, Texas*
Chenault, Bert R., *Houston, Texas*
Clark, William E., *Overland Park, Kansas*
Coleman, John H., *St. Louis, Mo.*
Cordiner, James B., Jr., *Baton Rouge, La.*
Eld, Aksel C., *Pittsburgh, Pa.*
Flood, James E., Jr., *Newark, Del.*
Gerbes, Otto, *Baytown, Texas*
Gilbert, Harry, *Bay Village, Ohio*
Helgren, Norman R., *Weeks, La.*
Hess, Donald M., *Louisville, Ky.*
Hobart, Vernon F., *Joplin, Mo.*
Hodson, John R., *Channelview, Texas*
Kane, Vernon H., *Texas City, Texas*
Kraemer, Herbert F., *Baton Rouge, La.*
Lewis, H. Clay, *Atlanta, Ga.*
Lynch, Edward H., *El Segundo, Calif.*
Mason, Edward A., *Lexington, Mass.*
McKelvey, James M., *Baltimore, Md.*
Merryman, John, Jr., *Cockeysville, Md.*
Michael, L. W., *Chicago, Ill.*
Monet, Gilbert P., *Wilmington, Del.*
Munns, William O., *Toronto, Ont., Can.*
Ratje, John D., *Borger, Texas*
Rock, Eugene T., *Edgewood, Md.*
Rosencranz, R., Jr., *Houston, Texas*
Schutt, Hermann C., *Boston, Mass.*
Schwartz, Clarence E., *Charlottesville, Va.*
Skinner, Loren C., *Memphis, Tenn.*
Slansky, Cyril M., *Idaho Falls, Idaho*
Stone, Louis, *Laurelton, N. Y.*
Tannich, Richard E., *Baytown, Texas*
Templeton, Hugh E., *Cincinnati, Ohio*
Vreeland, Ralph J., Jr., *Los Angeles, Calif.*

Associate Member

Adams, Frank S., Jr., *Augusta, Ga.*
Aman, John K., *Wayne, Pa.*
Annesser, Richard J., *Ann Arbor, Mich.*
Atchison, William E., *Baton Rouge, La.*
Bauni, Henry L., Jr., *Newport, Ark.*
Beroes, Charles S., *Pittsburgh, Pa.*
Boozalis, Theodore, *Houston, Texas*
Boozenny, Alex., *Henderson, Nevada*
Brooks, Leonard R., *Houston, Texas*
Byers, Richard N., *Toledo, Ohio*
Cassel, Robert F., *Summit, N. J.*
Chester, Geoffrey D., *Baton Rouge, La.*
Chocas, William, *Memphis, Tenn.*
Clark, Jerry C., *Texas City, Texas*
Clements, James S., *Decatur, Ala.*
Clinton, Sam D., *Oak Ridge, Tenn.*
Coaker, Anthony W., *No. Wilbraham, Mass.*
Cooper, Dale O., *Torrance, Calif.*
Corneille, J. L., *Montreal, Que., Can.*
Davis, Donald A., *Houston, Texas*
Davis, J. Rogers, Jr., *Philadelphia, Pa.*
Desnoyers, Paul J., *Somerville, N. J.*
Driscoll, William J., *Lorain, Ohio*
Edwards, Don B., *Charleston, W. Va.*
Erskine, Donald B., *Las Vegas, Nev.*
Esterhoy, Charles J., *Manville, N. J.*
Favreau, Robert L., *Aiken, S. C.*
Foss, Alan S., *Wilmington, Del.*
Fussel, Larry Neil, *Hammond, Ind.*
Gebert, Bob J., *Orange, Texas*
Gervasi, Gilbert, *Linden, N. J.*
Giove, F. C., *Oak Ridge, Tenn.*
Gosselin, Donald A., *Institute, W. Va.*
Graf, Frank A., *Idaho Falls, Idaho*
Griffith, D. Edwin, *Baytown, Texas*
Hagquist, Gerald H., *San Jose, Calif.*
Harris, Jay R., *Philadelphia, Pa.*
Hendrickson, M. Jay, *Pittsburgh, Pa.*
Hotchkiss, Leonard B., *So. Charleston, W. Va.*
Ing, Samuel, Jr., *Cambridge, Mass.*
Jackson, Jorge, *Maracaibo, Venezuela*
Jackson, Wayne Olin, *Somerville, N. J.*
Jones, Kenneth L., *Houston, Texas*
Hallee, Lawrence P., *Boston, Mass.*
Harrington, Richard F., *St. Albans, W. Va.*
Hasbrouck, Louis P., Jr., *Ridley Park, Pa.*
Hatcher, Jack M., *Van Nuys, Calif.*
Hohmann, John P., *Oakland, Calif.*
Hollis, James R., *Wyandotte, Mich.*
Jardine, D. A., *Kingston, Ont., Can.*

King, Kenneth, Jr., No. Wales, Pa.
Koon, Calvin S., Jr., Savannah, Ga.
Kordiak, Stephen M., Orange, Conn.
Kruse, Ronald E., Marcus Hook, Pa.
Lander, Joel R., Baytown, Texas
Lane, Thomas V., Richland, Wash.
Letts, Roger W. M., Old Greenwich, Conn.
Lin, Francis C. M., Pittsburgh, Pa.
Lloyd, Julius E., New Castle, Del.
Maginn, Robert A., West Orange, N. J.
Manning, Robert E., State College, Pa.
Martin, Phipps T., Aiken, S. C.
Marziani, A. W., Inglewood, Calif.
Mayer, Bernard, Wilmington, Del.
McGriff, Haskell H., So. Charleston, W. Va.
Merz, Gerald F., Aiken, S. C.
Meyer, Herbert W. H., Jr., Baytown, Texas
Meyer, Richmond G., Wyandotte, Mich.
Miller, Paul Mellis, Newark, Del.
Miller, Robert A., Dearborn, Mich.
Mings, Walter J., Whiting, Ind.
Moosavian, H., Cloquet, Minn.
Mulman, Morris, Edgewood, Md.
Narang, Rajinder K., Buffalo, N. Y.
Ord, Robinson, Jr., Niagara Falls, N. Y.
Ortt, William C., Sistersville, W. Va.
Pahl, Robert, Jr., St. Louis, Mo.
Parker, Harry W., Bartlesville, Okla.
Paul, Edward L., Sea Girt, N. J.
Phillips, Philip J., Long Island City, N. Y.
Piazza, Michael A., Kingsport, Tenn.
Pulaski, Alfred Steven, Brooklyn, N. Y.
Reed, Gordon A. D., Montreal, P.Q., Can.
Rickles, Robert Norman, Brooklyn, N. Y.
Riggs, Donald R., Baytown, Texas
Ringler, Donald B., Cumberland, Md.
Rives, James B., Jr., Orange, Texas
Rodgers, Robert B., St. Louis, Mo.
Rohner, Robert, Boston, Mass.
Roseberry, Roy B., Jr., Charleston, W. Va.
Roth, John A., Louisville, Ky.
Russell, Joseph L., Midland, Mich.
Rymarz, Ted M., Chicago, Ill.
Sabin, William W., Detroit, Mich.
Salmon, Warren A., Cambridge, Mass.
Sanders, R. G., Jr., Beaumont, Texas
Sayre, Clifford M., Jr., Wilmington, Del.
Schlager, Stephen T., Stamford, Conn.
Schmidt, John E., Jr., Charleston, W. Va.
Simon, R. H. M., West Springfield, Mass.
Smith, George C., Wilmington, Del
Smith, Gordon R., St. Paul, Minn.
Squires, Paul H., Wilmington, Del.
Stauffer, Harry C., Pittsburgh, Pa.
Stewart, Gary G., El Segundo, Calif.
Strausser, John R., Pittsburgh, Pa.
Tang, Walter K., Madison, Wis.
Thomas, Daniel J., Springfield, Mass.
Thornborough, Dale, Waukegan, Ill.
Traylor, Richard W., Texas City, Texas
Vinson, R. O., Lake Jackson, Texas
Wass, Donald M., Charleston, W. Va.
Weldon, R. Allan, Willow Grove, Pa.
Wen, Chin-Yung, Morgantown, W. Va.
Wilde, Peter V. D., Warwick, R. I.
Williamson, Thomas S., Kingsport, Tenn.
Willson, Dan H., Baytown, Texas
Zellars, W. A., Alvin, Texas
Zook, George E., Louisville, Ky.

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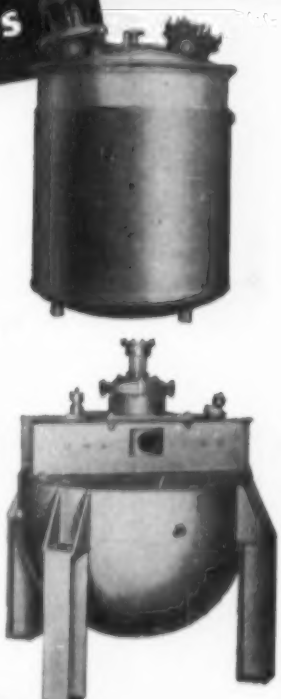

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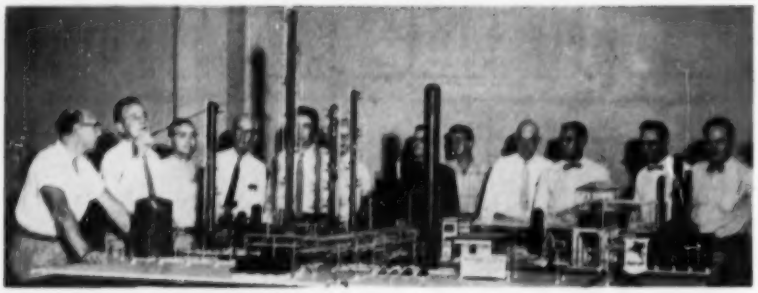


FINALIZING PLANT LAYOUT

Engineers from Socony Mobil and J. F. Pritchard meet to examine model of 9,000 bbl./day fixed-bed catalytic reformer, finalize piping and plant layout for unit Pritchard is engineering and to construct.

THE NEW OFFICERS . . .

◀ L., to r.: President Rushton, vice-president Holbrook, executive secretary Van Antwerpen, past-president Whitman.

. . . AND NEW DIRECTORS

◀ L. to r.: Wilhelm, Koffolt, Healy, Benedict. Picture of new officers of the Nuclear Engineering Division will appear in the February issue. They are: H. S. Isbin, U. of Minnesota, chairman; W. K. Davis, A.E.C., vice-chairman; C. E. Dryden, Ohio State U., secretary-treasurer; plus, on the Executive Committee, W. A. Rodger, Argonne; M. C. Leverett, G.E.; J. A. Lane, O.R.N.L.; and J. N. Clegg, Battelle.

LECTURERS & AWARD WINNERS

L. to r., top to bottom: Institute Lecturer W. K. Lewis; Junior Award winner Ted Weaver; Professional Progress Award winner R. R. White with president Whitman; Wm. H. Walker Award winner Edward Comings; Student Problem Contest first prize winner Don Cianci.

BOSTON SOCIETY

Mr.'s & Mrs.'s: James Baird; A. W. (Bud) Fisher, Jr.; S. B. Zdonik; Walter M. Davis.

PRESS CONFERENCE

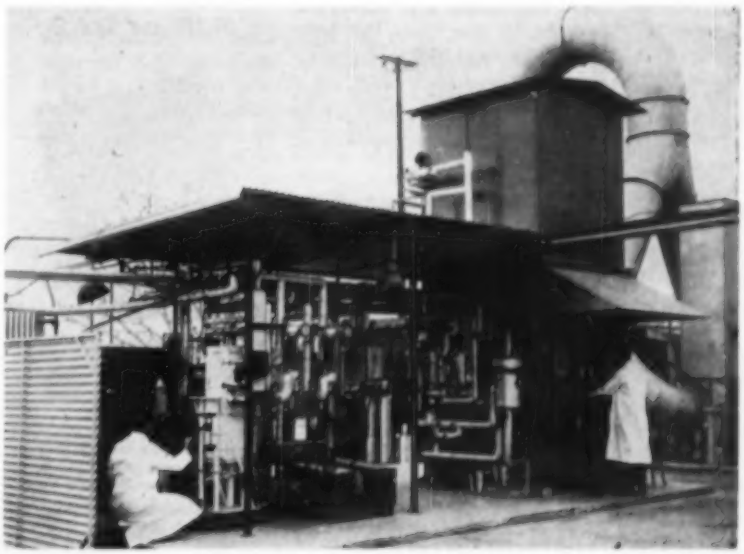
Chief of Naval Operations Arleigh A. Burke, commenting on role of fleet in recent Suez crisis, with, l. to r., Comings, Rushton, Donovan, White, and Whitman.

BOSTON RANDOM

L. to r., top to bottom: Executive secretary Van Antwerpen's roundup of committee chairmen; Heat Exchangers Subcommittee of Equipment Testing Procedures Committee; Bob York's Public Relations Committee; Coke time at the special Student Session with General Committee chairman James Donovan the center of attention; on TV, Rushton & Comings explaining significance of A.I.Ch.E. Annual Meeting to interviewer Jonathan Karas, a New Hampshire Univ. physics prof, to whom they presented A.I.Ch.E. citation in recognition of his success in popularizing science and technology over TV and radio.

PILOT PLANT

Fluor Corp., Ltd. has installed pilot plant facilities at a two-acre area in Whittier, Calif. and will actively seek industrial contract research in the petroleum, chemical, and petrochemical industries. About 30 technologists staff the Whittier installation.



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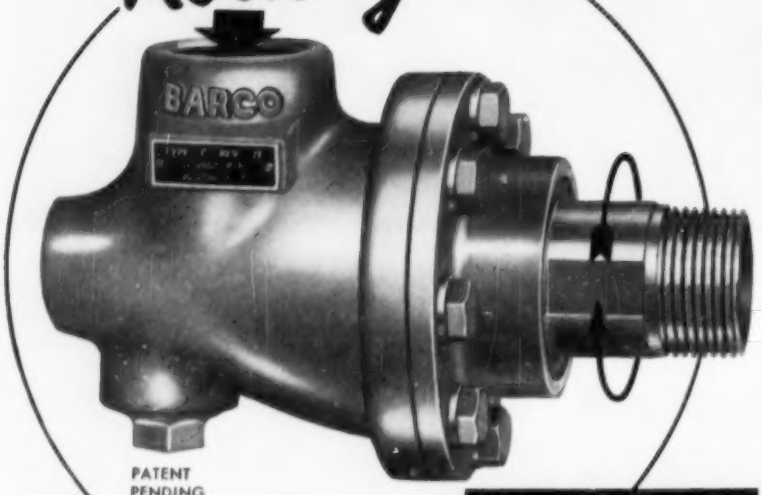

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INSTITUTIONAL NEWS

The new chemistry and chemical engineering building at Case Institute of Technology in Cleveland. The $1,800,000 structure provides 88,000 square feet of modern laboratory, classroom, office and research space under one roof. The third major addition to the Case campus, the new building provides much highly specialized equipment, including a shielded "hot" lab for nuclear studies.

"More than 5,000 companies are being slowed down by the need for an additional 50,000 engineers," says Industrial Psychology, Inc., national psychological research organization. "Industry used one engineer for each 400 employees 75 years ago. Today, the demand is one engineer for every 40 employees. Last year industry could have used 40,000 new engineers against the 22,000 who actually got their degrees. Scientists, designers, other types of technical personnel, and even skilled workers are in the same demand."

While these figures include all types of engineers, they are thought to be generally applicable to the chemical industry in particular. What concrete steps can be taken immediately to alleviate this situation? Industrial Psychology suggests:

1. Study job assignments in your technical departments.
2. Make job assignments in terms of psychological potential.
3. Employ engineering students for part-time work, then later develop them into full-time engineers.
4. Use retired engineers in your locality as consultants. □

Pratt Institute, Brooklyn, N. Y., is going to put an entirely new curriculum in engineering into effect. Basis will be a common two-year curriculum for chemical, electrical, industrial and mechanical engineering students, with emphasis on mathematics and science without specialization, except for a minor amount in the junior and senior years. Students will not have to decide on a field of specialization for two years, and the third, fourth and fifth graduate years can be taught by specialists with a much higher grade of student. □

Two ammonia synthesis separation plants, a urea plant in Japan, and an ammonium sulphate-from-gypsum plant in Italy, are among the new projects of Chemical Construction Corp. in its planned expansion of engineering design and construction services. Chemico, since its purchase from Cyanamid by Electric Bond and Share, is operating as an independent subsidiary. □

Dow Chemical has purchased a 50% interest in Productos Quimicos Mexicano, S.A., a producer of caustic soda. Plans call for an immediate doubling of the Mexican company's plant capacity. □

An industry exhibit open to the public at large is planned as part of the activities of the Second Cuban Congress on Petroleum to be held in Havana May 5-11, 1957.

There will be six working sections at the Congress: geology, geophysics and geochemistry; drilling and production; processing, distribution and utilization; research, development and testing; education and training of personnel; and management, economics and law.

Many speakers will discuss the nascent Cuban oil industry, but the Congress also desires papers of a general character so that all aspects of the industry will be fully covered. Papers should be on hand by March 1, 1957. Offices are in Edificio Habana 800, Havana, Cuba. □

The Government of Jamaica, B.W.I., has eliminated or substantially liberalized its industrial income tax laws and import duties in a move to stimulate capital investment on the island by the American chemical industry.

Companies recently established under Jamaica's Industrial Development Program include producers of soap, gypsum, paint, cement, foam rubber goods; and plans show that the paper, glass, and steel industries will be active on the island in the near future. □

A contract for the design of a nitric acid plant at Monclova, Mexico, has been awarded to the Engineering Division of Societe Belge de l'Azote et des Produits Chimiques du Marly (S.B.A.) of Liege, Belgium. Companies awarding the contract, Saint-Gobain and Batignolles-Chatillon, are part of a group of French and Mexican companies installing an industrial complex for the production of nitrogenous fertilizers. S.B.A.'s own nitric acid process will be used in the plant. □

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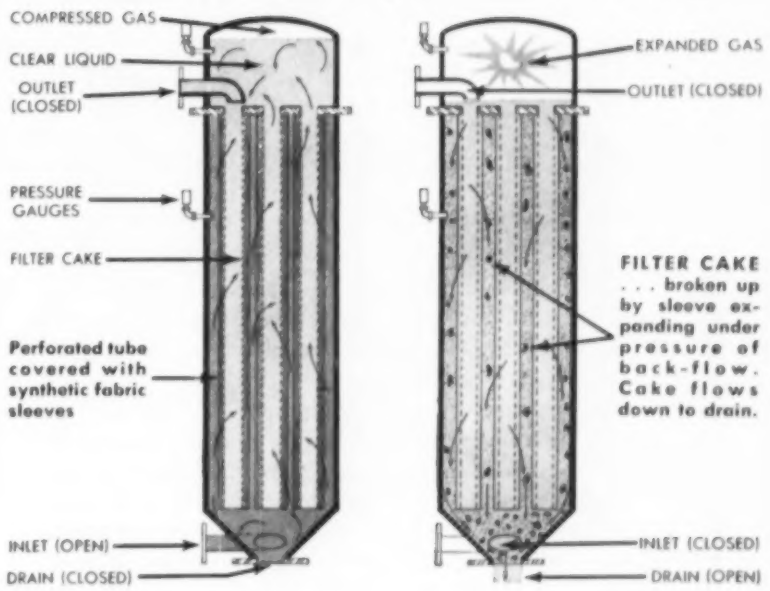

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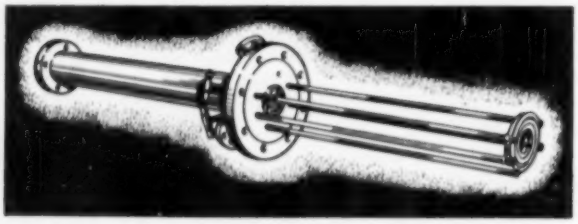

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OVERSEAS NEWS

At the recent opening of the Fourth International Chemical, Rubber and Plastics Exposition in Paris, the M. W. Kellogg and Societe Kellogg joint display attracted considerable attention. Here, M. Maurice Lemaire, French Minister of Industry and Commerce (left of center), congratulates company representatives on their booth.

A 50,000 ton/year urea plant has gone on-stream at the Staatsmijnen works in Limburg, Netherlands. □

Polyvinyl chloride is now in production at the Takaoka plant of the Japanese Geon Co., an associate company of B. F. Goodrich Chemical. New plant has initial annual capacity of 6,500 tons, will be expanded within the year to the largest polyvinyl chloride plant in the Eastern Hemisphere. □

The prospective site of a neoprene synthetic rubber plant in Northern Ireland is a 381-acre tract near Londonderry now under option to Du Pont Co. (United Kingdom) Ltd. Assuming successful completion of engineering and economic studies now under way, plant construction will probably begin early in 1957. □

Construction of a nuclear and commercial graphite plant at Newcastle, England, will begin in the spring of 1957. Scheduled for full production in late 1958, with an initial capacity of 15,000 long tons a year, the plant will be operated by Anglo-Great Lakes Corp., Ltd., a new company organized in England by the electrode division of Great Lakes Carbon Corp. and four British companies. □

A contract for the construction of three 16,000-ton ore ships to transport bauxite from Surinam, Dutch Guiana, to the U. S. has been awarded to Ottensener Eisenwerk, Hamburg, by Olin Revere Shipping Corp., an affiliate of Olin Revere Metals Corp., N. Y. The ships are specially designed to enable them to carry 14,000 tons of ore (as compared to 8,700 limit previously) and still have shallow enough draught to clear the shallow bar across Surinam harbor. □

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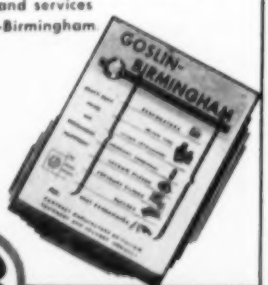

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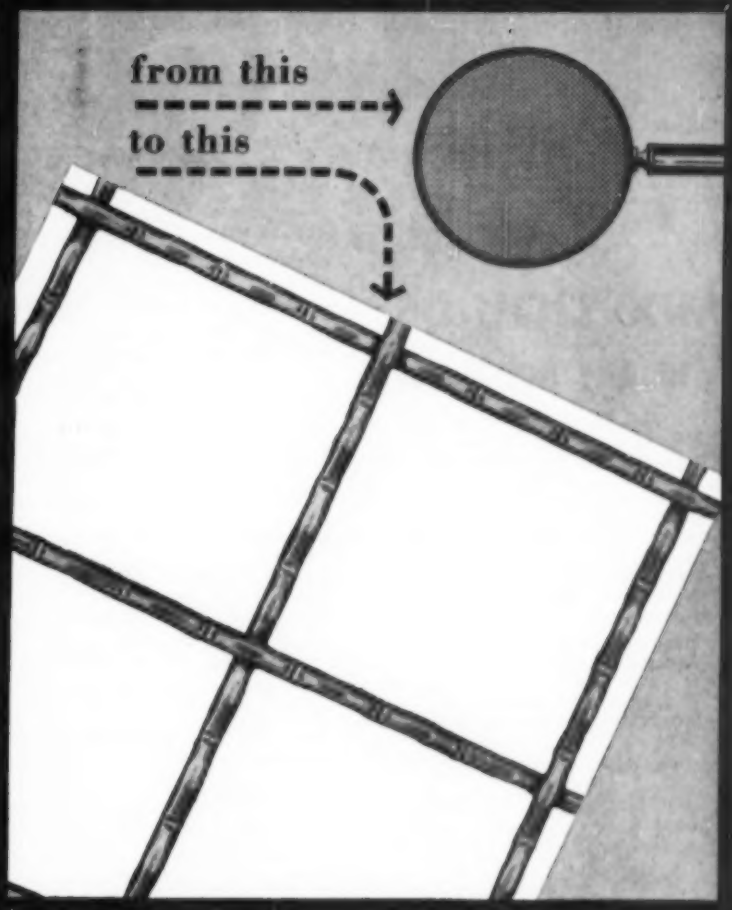

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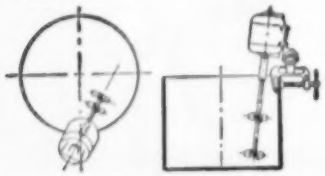

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METALS HOLD SPOTLIGHT AT LOCAL SECTION MEETINGS

Capitalized cost, nuclear energy, petroleum subjects also discussed as sections enter most active period of year.

It wasn't until 1932 that a process was developed that could produce titanium in large enough quantities to be of much use, R. A. King, Republic Steel Corp., told the October meeting of the **El Dorado Section** (*D. S. Thomas*). But the cost was still so high that by 1946 only two tons of titanium were produced a year. Today, production is up to 14,100 tons, with four companies producing the material. Main cause of the rapid rise in production is the wide application of titanium in the aircraft industry where the metal's lightness, high strength and inertness is highly prized. But it is also finding wider and wider application in the chemical, food, and marine industries. Big problem is still cost—about $13.00 per pound.

Rare Metals

The market value of five rare metals recovered in zinc smelting is greater than the market value of the zinc in the same ore, according to J. L. Hart, National Zinc Co., speaking before the November meeting of the **Oklahoma Section** (*L. A. Warzel*). Recovery costs are high for these rare metals, but their utilization has expanded rapidly since World War II. The five metals are: cadmium, gallium, germanium, indium and thallium. Each has unusual properties which have given them major uses for special applications.

Alloys

To be serviceable at high temperatures, a metal must have satisfactory melting point, coefficient of thermal expansion, and thermal stability. Emphasizing those points, E. N. Skinner, International Nickel Co., went on to explain to the November meeting of the **East Tennessee Section** (*R. F. Hunt, Jr.*) that the principal suitable metals are iron alloys containing various amounts of nickel and chromium, although molybdenum is a promising new metal for alloying. The composition of the surrounding atmosphere has a great effect on the serviceability of a metal. In addition, alternate heating and cooling or quenching will affect metals differently. Much remains to be done in this entire field, since potential service requirements far exceed presently available materials.

Capitalized Cost

Using an equation, F. C. Jelen, Solvay Process Division (Allied), discussed the Comparisons of Alternatives by Capitalized Cost. The equation is $K = CF_m$, in which:

K = capitalized cost
C = initial equipment cost

$$F_m = \frac{(1+i)^m}{(1+i)^m - 1}$$

i = interest rate
m = number of years service life

Jelen, speaking before the December meeting of the **Rochester Section** (*F. L. Wells*), went on to illustrate the application of capitalized cost as a method of reducing cost time factors to a common basis. Jelen's method and examples were published in detail in the October, 1956, issue of *CEP*.

In modern synthetic fiber plants, one out of every ten employees is a skilled, technically trained person, said R. W. Sudhoff, Chemstrand Corp., to the December meeting of the **National Capital Section**. The synthetic fiber field, Sudhoff went on, is not a field for the amateur. The integration of raw materials, monomers, and fiber manufacture, essential to low costs and top quality, necessitate a rather large operation before initial sales can be realized. In the case of new items, a

(*Continued on page* 124)

Ex-president of A.I.Ch.E. Walt Whitman inspects facilities at Battelle West Jefferson Hot Cell Laboratory on visit to Akron section.

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News of the Field
FROM LOCAL SECTIONS

(*Continued from page 122*)

large amount of field development work must be done before the huge expenses of initial process and product development can be erased.

Fuels and Hydrocarbon Extraction

For maximum efficiency and performance, each of the new engines being developed requires its own special fuel, W. J. Sweeney, Esso Research and Engineering, told the December meeting of the **New Jersey Section** (*W. E. Deyerle*). The oil companies are devoting a considerable amount of research to the development of new fuels in order to be able to make the required fuel available when automobiles with the new engines appear on the market. Main types of engines which may appear in automobiles are the turbine, free piston, and modern diesel.

Liquid ammonia is an economical solvent for extracting hydrocarbons since ammonia is inert toward hydrocarbons, is volatile and easily recoverable, explained M. R. Fenske, Penn State Univ., to the November meeting of the **Philadelphia-Wilmington Section** (*J. A. Guthrie*). Many extractions have been made to show the usefulness of a 20-stage extractor plus the ammonia solvent system in separating hydrocarbon mixtures for petrochemicals, for aromatics or olefins, for octane improvement in hydroformates as well as cracked naphthas. The extractions were carried out at normal temperatures, with water used to reduce hydrocarbon solubility, and methylamine as a useful pro-solvent when low solubilities were encountered. The extractor developed can be modified to contain a total of from 5 to 20 theoretical stages with any division desired between enriching and stripping in batch or continuous operation.

Nuclear Energy

Chemical engineering activities in the nuclear field was the subject of D. Sinizer, Atomics International (Division of North American Aviation, Inc.), at the November meeting of the **Southern California Section** (*R. D. Sheeline*). Sinizer explained that removing fission products from reactor fuel is a chemical engineer's nightmare. Highly radioactive materials are put into solution, the fission products are removed, and then the radioactive materials must be recovered in

(*Continued on next page*)

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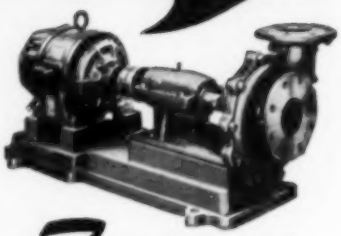

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- Pumps speeds can be varied to suit the driving media and operating conditions.

CONSTRUCTION ADVANTAGES

Pump casings are vertically split for easy accessibility. Mounted on a swivel to permit placing discharge in any desirable position. Pump openings, both suction and discharge, flanged to permit easier connection and disconnecting to joints. One-piece impellers, securely attached to shaft by stout key and lock nut, or threaded, give long service. Pump bearings mounted in sturdy frame horizontally split for easier accessibility. Extra long stuffing box provides for oversize stuffing. Mechanical seal also available for minimum leakage. Pump coupling flexible for direct connection to drivers or can be arranged for belt drive. Pump speed, pump openings, etc. are selected to suit your particular requirements.

Write for Bulletin No. 107

FREDERICK PUMPS

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metallic form. Large underground storage capacity is required for the fission products. Atomics International expects to simplify, and make more economical, the process of removing these products.

There is considerable variation in the degree to which nuclear work has been incorporated into engineering curricula in the various engineering schools, said D. L. Katz, University of Michigan, addressing a joint October meeting of the **Central Oklahoma** and **Tulsa Sections** (*G. L. Farrar*). This variation, Katz continued, is quite in order, since each school should recognize the place of nuclear energy in a manner appropriate to its purpose. Engineering faculties are finding many interesting research problems created directly or indirectly by the nuclear field. It follows that the technical material in our engineering courses will absorb many examples from the nuclear field.

Brazilian Petroleum

The Brazilian petroleum industry is undergoing a period of rapid growth, said F. C. Williams, speaking to the December meeting of the **Northern California Section** (*J. C. Orrea*). Its primary objective, Williams said, is to meet Brazil's own requirements of oil products, particularly gasoline. Domestic Brazilian crude production, while still small, is being increased, and the large sedimentary basins are being explored. Several new refineries have been built and a large one at Rio de Janiero is in the design stage.

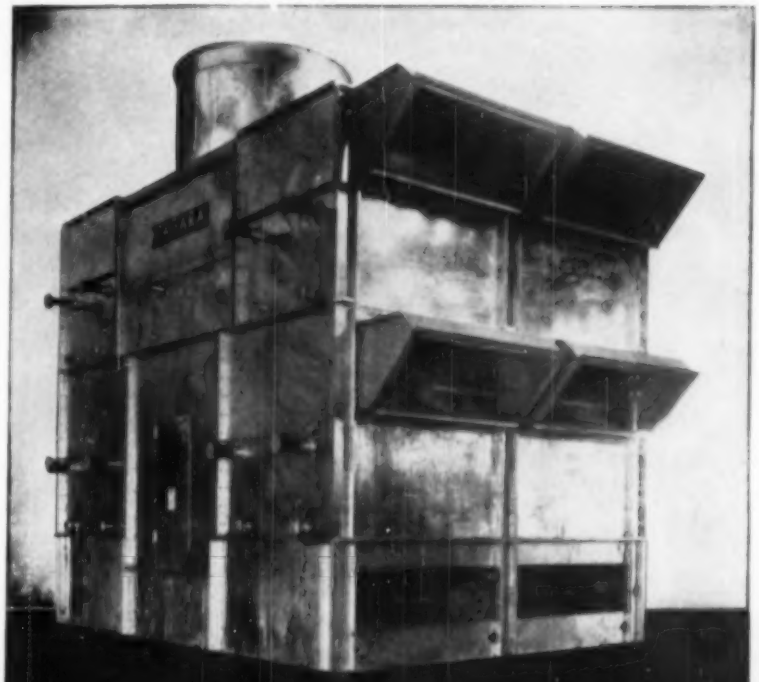
Synthetic sapphires were the topic of discussion at the **Pittsburgh Section's** (*R. Frumerman*) November meeting. A. K. Seemann, Linde Air Products Co., explained that the synthetic gems are needed in many segments of industry, as well as in watches and watt-hour meters. Industrial applications come in electron tubes, mercury arc lamps, light pipes, and windows in furnaces for measuring temperatures.

Also Meeting . . .

Rhode Island Section (*J. L. Campanella*) heard, in November, V. C. Rose, Jr., discuss the uses and production of the rare earths. . . . **Northeastern New York** engineers were brought up to date on the activities of E.C.P.D. in promoting professional development, and some of the problems involved in the commercial development of solar energy at their December meeting . . . **Western Massachusetts** (*R. T. Bogan*) went on a vicarious tour of

(*Continued on page 126*)

Thirty Million B. T. U. CAPACITY



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The NIAGARA Aero HEAT EXCHANGER cools liquids and gases by evaporative cooling with atmospheric air, removing the heat at the rate of input, controlling temperature precisely. You save 95% of cost of cooling water; you make great savings in pumping, piping, power; quickly recover your installation cost.

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In CHEMICAL PROCESSES this is successfully used in cooling liquids and gases, chemical reactions, condensing distillations and reflux cooling.

Write for complete information; ask for Bulletins 120 and 124. Address Dept. EP.

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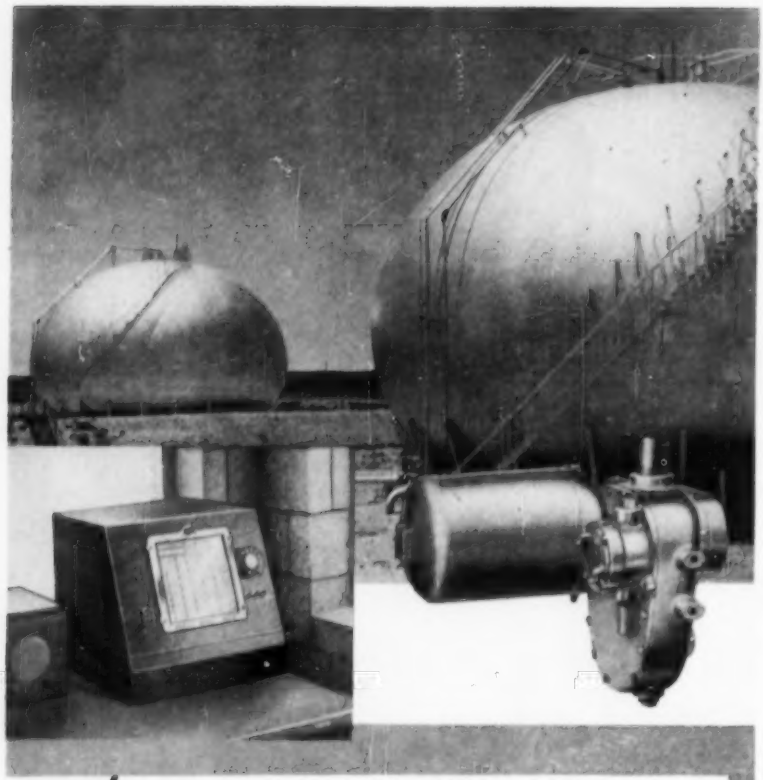

"Varec" PULSE CODE KEEPS "TAB" ON OKAN PIPELINE

Keeping a pipeline flowing smoothly is a mighty big job . . . that's why OKAN PIPELINE wants the latest in automatic equipment to speed its work. An important part of this equipment is the "Varec" PULSE CODE Telemetering System, which signals the liquid level of storage tanks at terminals and along the line. In addition to this function, it turns valves on and off by remote control.

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You may want to cut your operating costs by using a "Varec" PULSE CODE System. Equipment for reporting either spot or average temperature, in addition to liquid level, is now available.

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News of the Field

FROM LOCAL SECTIONS

(*Continued from page 125*)

the Middle East in December guided by Mrs. L. Johnson, wife of a Springfield minister . . . **Syracuse Section** (*A. E. Skrzec*), a fledgling, heard an October talk on Primitive Engineering . . . **Coastal Georgia** (*J. M. Mallory*) heard a talk on the S-W Anderson Fiber Press at its October meeting . . . **New Great Salt Lake Section** (*B. J. Pope*) devoted much of its October meeting to the subject of epoxy resins and discussion of preparations for the 1958 national meeting in Salt Lake City . . . **Savannah River** (*G. L. Tuer, Jr.*) reports on two meetings: October, when recovery of titanium by placer mining was discussed, and the November meeting, where A.I.Ch.E. ex-president Walt Whitman gave his talk on Atoms for Peace . . . Fluid coking, including full process details, held the floor at the November meeting of **Northern California** (*R. R. Hughes*) . . . **Tulsa Section** (*J. C. Reidel*) held a joint meeting with the local A.C.S. section on the subject of Water Treating . . . At the **Atlanta Section's** (*N. R. Maleady*) November meeting, F. Bellinger talked on his experiences as advisor in industrial chemistry to the Egyptian National Research Council. . . . In October, the **Rochester Section** (*B. Eilinger*) heard, from Shelby Miller, all about the Dissatisfied Chemical Engineer . . . **Chicago Section** heard Stuart McLain discuss Reactors of the Future at its November meeting.

NEW SECTION—NEW CLUB

Council has announced the approval of the Pensacola Chemical Engineers Club as the new **Pensacola Section** of A.I.Ch.E.

The Section, which had been in successful operation as a club for some 2 years, has approximately 107 members, has held regular meetings for some time, has been active in the entire field of professional development and advancement.

New officers of the section are: G. B. Hughey, chmn.; A. C. Coggeshall, vice chmn.; and J. P. Krumbein, sec.-treas.

New Club

The new club is also in Florida. It is the **Florida Chemical Engineers' Club**, at Gainesville, Fla. The first meeting of the club was highly successful, with 25 dues-paying members having already signed up.

people

Reuel C. Stratton is named assistant director in charge of chemical and nuclear research in new Department of Research set up by the Travelers Insurance Co. Mr. Stratton has been with Travelers as assistant superintendent of the casualty engineering and loss control department.

Stratton

Gordon W. McBride, chemical engineering consultant, joins the Washington, D. C. staff of Carbide and Carbon Chemicals Co. Mr. McBride has been in consulting practice in Washington since 1939, except for service with the Dept. of Agriculture during World War II.

Richard R. Bukacek named as instructor on the staff of the Illinois Institute of Technology, Chicago.

SEABORG TO RECEIVE PERKIN MEDAL

Glenn T. Seaborg, Nobel Laureate and Director of Chemical Research, Radiation Laboratory, Univ. of Calif., is to receive the 1957 Perkin Medal of the American Section, Society of Chemical Industry.

Nopco Chemical Co. announces appointment of **Michael Sandor** as technical manager of their newly-formed Metal Processing Chemicals Department.

Robert J. DeLargey, resident manager of Food Machinery and Chemical Corp.'s Westvaco Chlor-Alkali plant at South Charleston, West Virginia, promoted to post of director of engineering for FMC's Chemical Division.

De Largey

Clifford F. Rassweiler, vice-chairman of the board and vice-president for research and development of the Johns-Manville Corp., New York, is chosen president-elect of the American Chemical Society. Dr. Rassweiler will head the Society in 1958.

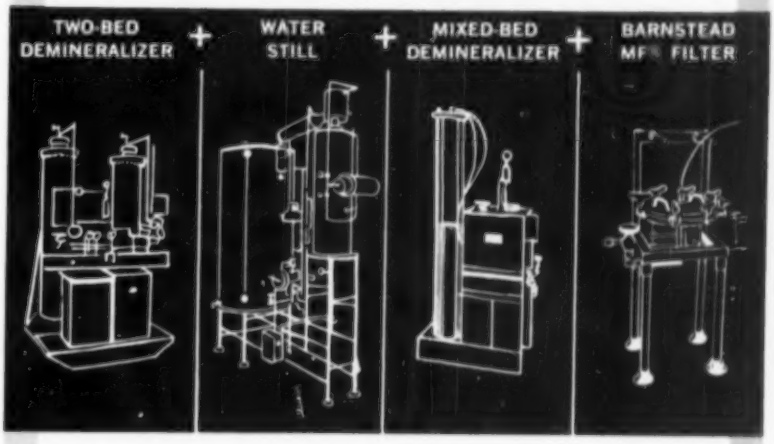
Allied Chemical & Dye Corp. appoints **Louis C. Goode** as plant manager of the Moundsville, W. Va. plant of their National Aniline Division.

PUREST WATER

(HOH ABSOLUTE)

10,000,000° OHM Water, Free of Bacteria and other submicroscopic Particles, Organics and Silica.

Closest thing to HOH ABSOLUTE . . . an entirely new standard of water purification by Barnstead now makes new advances possible in Chemical, Electronic, and Nuclear fields.



The purification of water often requires special engineering, and a broad consideration of accessory equipment. The above combination of Water Demineralizers, Water Still, and Barnstead MF Filter, operated in series, will produce 10,000,000 OHMS water in production quantities . . . free of bacteria, organics and silica.

Whatever your water purification problem, Barnstead engineering coupled with Barnstead's extensive line of Pure Water equipment has the authoritative answer. Write today!

Catalog "G"
Describes line of water stills from ½ to 1000 gph.

Catalog 127
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MF Filter, filters out particles to 0.45 micron

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Program Control Panel used at Delaware Station, Philadelphia Electric Co. to automatically start and stop their W&T Slime Chlorination System.

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controls slime in power generating plants

The Philadelphia Electric Co. has W&T chlorination equipment installed in their steam-electric generating stations to prevent slimes from fouling the turbine condensers and lowering the efficiency of the units. Maintaining cooling efficiency saves enough fuel to more than pay for the treatment.

Chlorination is controlled from a W&T Program Control Panel like the one pictured. Operators preselect chlorine dosage and treatment times. Chlorination is started and stopped automatically in accordance with the preselected schedule. The result is positive slime control without requiring personnel to supervise each treatment and without the expense of chlorinating continuously.

For information about W&T Slime Control Systems write for Bulletin CD-42.

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IN CANADA W. C. HARDESTY CO. OF CANADA LTD. TORONTO

people

(*Continued from page 127*)

Key personnel changes are announced by Monsanto. **Richard J. Kozacka** becomes plant manager of the Inorganic Chemicals Division plant at Everett, Mass. He succeeds **Russell L. Miller,** who becomes manager of the Queeny plant in St. Louis. **Howard L. Minckler** is named director of manufacturing for the Organic Chemicals Division, replacing **Robert M. Morris,** who is appointed assistant general manager for the division. **John F. Thompson** becomes general superintendent of Inorganic Division manufacturing in the Krummrich Plant, Monsanto, Ill.

Kozacka

Robert J. Schatz, associate director of research for Monsanto's Plastics Division, is promoted to associate director of research at the division's Texas City laboratory.

E. T. Harding, assistant to the general manager of the Research & Development Departments for Corn Products Refining Co., is promoted to the Industrial Relations Department as coordinator of technical recruiting and placement. Mr. Harding is currently Secretary of the Chicago Section of the A.I.Ch.E. and publicity chairman of the December, 1957, meeting.

Harding

W. J. Dyck has joined Hydrocarbon Research, Inc., New York, will be stationed in Duesseldorf, Germany, as project engineer.

Shell Chemical names **John F. Roorda** to post of assistant technical superintendent at their Houston plant.

J. William Haun, formerly of Monsanto, joins General Mills research staff as head of the Chemical Engineering Department. Dr. Haun will direct all of General Mills' chemical engineering research and pilot plant activities.

Haun

Robert E. Ward appointed director of manufacturing of the New York Air Brake Co.

Polymer Chemicals Division of W. R. Grace & Co. names **John R. Davis** to staff of their Baton Rouge, La. polyolefin resin plant. For the past 8 years, Mr. Davis has been connected with Shell Chemical Corp.

Col. Martin B. Chittick, American Mineral Spirits Co., has received the Achievement Award of the National Lubricating Grease Institute in recognition of his outstanding services in the development of the International Standard Method of Lubricating Grease Classification.

Carl A. Vill named assistant to the vice-president of Chemical Construction Corp.

E. C. Sargent is named president of the Zirconium Corp. of America in Solon, Ohio. Mr. Sargent was formerly with Vitro Engineering Division and the AEC.

Sargent

Houdry Process Corp. announces advancement of George F. Hornaday to associate manager of research and development and of **D. Eugene Norris** to assistant process sales manager.

James G. Couch, formerly with Du Pont, is named manager of the production department engineering section for U. S. Industrial Chemicals Co.

Arthur Komorowski is appointed production manager of the new acetylene chemical products plant at General Aniline & Film Corp., Calvert City, Ky.

Edward A. Murray, textile consultant, becomes director of instruction in the School of Textiles at North Carolina State College.

MADE MANAGING EDITOR

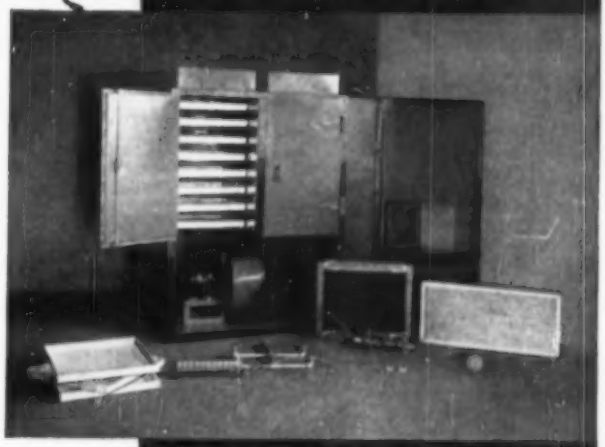
William E. Anderson has been made managing editor of *CEP*, effective January 1st. Mr. Anderson joined *CEP*'s staff late in 1955 as associate editor. Previous to this he had been associate editor and production manager of *World Petroleum*, a magazine serving the international petroleum industry. Trained at the State University of Iowa, Columbia College, and Columbia Graduate School, Mr. Anderson brings to *CEP* a sound background in journalism and publication practice.

(*Continued on page* 130)

When You can't "Sweat it out" in a hurry...

THERE'S A

TRAY DRYER



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TO DO THE JOB!

For wet powdered, sensitive or unstable materials that must be dried slowly and with utmost care

Sargent builds these dryers with any number of trays; single or multiple stacked; one or more deep; for highly varied drying speeds and material loads.

The dryer above, for example, is installed in a cotton-seed oil processing plant. Another SARGENT design, for wet powdered and unstable materials, has 40 trays, 10 high, double stacked, 2 trays deep. The entire interior of this dryer-evaporator (including trays, fan, housing, inlet vanes, baffles, exhaust ports, etc.) is of a special type stainless steel. Air splitters and baffles distribute an even air flow across every tray. Guaranteed performance: a minimum of 100 lbs. water removed from a 200 lb. charge in 8 hours at 60° C.

SARGENT dryers are designed with product protection paramount. Every dryer, every new product, is "proven out" in Sargent's own expertly staffed Drying Research Laboratory, for *your* protection. Unusually rugged construction, economy and dependable guaranteed performance are Sargent standards.

There's a SARGENT dryer to do the job for the process industries — conveyor or tray; pole or tunnel; stationary or rotary. High speed or low, heavy capacity or light; continuous or batch methods. All Sargent-designed for the specific job. For more details, write

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FREE TRIAL

Write today for a generous free sample.

Dept. 3013

first in silicones

DOW CORNING CORPORATION
MIDLAND, MICHIGAN

people

(*Continued from page 129*)

New president of Goslin-Birmingham Manufacturing Co., Birmingham, Ala., is **John W. Little.** Mr. Little, who is also made a member of the board, succeeds **Joseph T. Hartson,** who retired January 1.

Little

Lyman A. Bliss is named president of Union Carbide Nuclear Co. Mr. Bliss was closely associated with Union Carbide's participation in the development of the gaseous diffusion process and other activities of the Manhattan Project.

Martin E. Gluckstein joins the research laboratories of Ethyl Corp. in Detroit as a chemical engineer in the chemical research group.

General Aniline & Film Corp. names **Lester B. Woolfenden** as plant manager of their acetylene chemical products plant at Calvert City, Ky.

Edward F. Wagner appointed by Witco Chemical Co. to newly-created post of manager of development.

Frederick M. Belmore, special assistant to the president of Mallinckrodt Chemical Works, heads the company's new Special Metals Division. Mr. Belmore was formerly with the U. S. Atomic Energy Commission.

Belmore

Carbide and Carbon Chemicals Co. announces appointment of **W. C. Heidenreich,** superintendent of their Niagara Falls plant, as associate director of Carbide and Carbon's general industrial relations department.

Appointment of **Herman E. Meadows** and **George F. Ham** to the technical service staff of Diamond Alkali Company's chlorinated products division is announced.

New staff member of Halby Chemical Co., Wilmington, Del., is **F. W. Sullivan III,** formerly with Houdry.

New chief engineer of Glidden Co. is **James W. Pollard, Jr.** He will be responsible for integration of engineering in the five major company divisions.

Association of Consulting Chemists and Chemical Engineers announces election of **Foster Dee Snell,** president of Foster D. Snell, Inc., New York, as vice-president for 1957.

T. M. Newsom promoted to senior chemical engineer at Humble Oil & Refining.

Leonard Seglin appointed by Food Machinery and Chemical Corp. as manager of engineering development for their new Organic Chemicals Division. Mr. Seglin was formerly with Ethyl Corp. and with Westvaco Chlorine Products Corp.

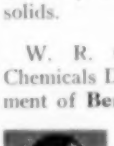
Seglin

Sun Oil Co. names **Frank W. Bowen** to position of refinery engineer at Marcus Hook, Pa.

Albert F. Stahl joins the process research section of Emery Industries, Inc., Cincinnati, Ohio. He will aid in research on fatty acids and their derivatives.

Three authorities in their respective fields are promoted to scientific advisers at Armour Research Foundation of Illinois Institute of Technology, Chicago. They are: **George Goldfinger,** specialist in polymer chemistry; **C. Roland McCully,** physical chemist; and **Frederic V. Schossberger,** authority on the crystal structure of solids.

W. R. Grace & Co.'s Polymer Chemicals Division announces appointment of **Berndt K. Lyckberg** as general manager of its new high density polyethylene plant in Baton Rouge, La. Mr. Lyckberg has been associated with the manufacture of synthetic polymers and the plastics industry for the past 17 years.



Lyckberg

ADDENDUM

It was reported in *CEP* (Dec., 1956) that **Chalmer G. Kirkbride** had resigned as president and chairman of the board of Houdry Process Corp. to join the Sun Oil Co. It should be added that Mr. Kirkbride also remains a member of the Board of Directors of Houdry.

(*Marketers on page* 139)

CHEMICAL ENGINEERS!

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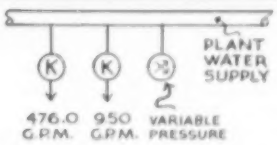
* KATES Direct-Acting Flow Rate Regulators are complete in themselves, requiring no outside connections except inlet/outlet piping; for light slurries, clear liquids, and many suspensions; hold constant flow despite 125-psi jumps or drops in inlet-to-outlet pressure.

Economy may not be your principal reason for selecting a Kates regulator, but added to the single-unit compactness and no-hunt, no-lag features it is certainly a valued extra. And you will save on maintenance, too. Kates regulators are designed to eliminate wire-drawing, and the only packing is on the infrequently-used dial stem.

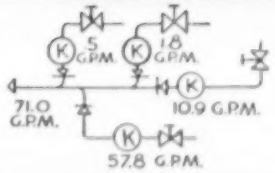
Write us for more details on the unique operating principles and practical design features of Kates flow rate regulators. But first, here are some of the problems that Kates has solved for others — *economically.*

PROCESS WATER CONTROL



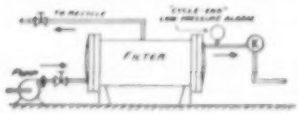
Pressure of most plant water fluctuates badly — whether it comes from city mains or in-plant pumps. If you need selected-constant flow, from 0.02 to 550 GPM, DON'T build a system. Install a Kates.

PROPORTIONATE BLENDING CONTROL



Where many ingredients go into one blend, and must be in exact proportion, a control *system* for each ingredient would cost plenty. But a Kates control on each feed does the job inexpensively, and each unit can be reset for a blend change.

PRESSURE FILTRATION CONTROL



As filter cake builds up, a constant valve-jockeying is needed to smooth out flow. A Kates control in the effluent compensates for rising pressure drop, keeps filter at best rating.

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Assignments will be primarily process design and economics — determination of overall process requirements, selection of processing steps, and economic evaluation of processes. Other work may include market analysis, industrial surveys, and technical assistance to sales.

Write to the head of our Personnel Department, Mr F B Stratford.

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Chemical engineer needed for expanding plant scale research program on newly developed petroleum and petrochemical process equipment.

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Job requires sound knowledge of chemical engineering principles and ability to deal with practical plant problems. Prefer man with one to five years experience.

Give full details of education, experience, desired salary, availability date and references. All inquiries will be considered promptly and held confidential.

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Esso Research Center
Employee Relations-C

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PROCESS DEVELOPMENT

Chemical engineers required for process development, both in working out new refining methods and in improving existing processes throughout the Jersey Standard interests. Small scale exploratory research is included in this work as well as pilot plant studies.

PROCESS ENGINEERING AND DESIGN

Chemical engineers are needed in process engineering development, design and economics; to convert our new laboratory processes and improvements to operable and efficient commercial plants on a world-wide scale; to solve problems in planning, designing, estimating costs, and comparing possibilities from a business (cost and profit) point of view.

MANUFACTURING ENGINEERING

Chemical engineers required in plant operations to develop means of obtaining increased efficiency in throughput, product yields and consumption of utilities, chemicals and catalysts; to conduct large plant scale tests on operating equipment to study limitations to capacity and efficiency.

Chemical engineers required for work in manufacturing economics, planning and coordination.

RESEARCH AND DEVELOPMENT

Chemical engineers and chemists needed for research and developmnt work on valuable chemicals from petroleum raw materials such as synthetic rubbers, plastics, alcohols, synthetic detergents, plasticizers and surface coatings. Similar development work is directed to the more conventional petroleum products which include all types of power fuels and lubricants.

BS, MS, and PhD Chemical Engineers with up to ten years' experience are invited to investigate. Give full details of education, experience, desired salary, availability date and references. All inquiries will be considered promptly and held confidential.

Mail Replies to:

ESSO RESEARCH CENTER

Employee Relations–C

P.O. Box 51 **Linden, N. J.**

ESSO RESEARCH & ENGINEERING COMPANY

Esso Standard Oil Company (East Coast Division)

(Domestic Subsidiaries–Standard Oil Company (New Jersey))

Sets Up New Development Department—

Top Scientists With 0 to 5 Years' Experience Needed by Largest Producer of Synthetic Organic Chemicals

Carbide and Carbon Chemicals Company, a Division of Union Carbide and Carbon Corporation, recently announced the reorganization and expansion of its Development Department. It will use the tools of applied research, chemical engineering research, and pilot plant operations to determine the most economical and technically feasible method for producing a chemical product with the highest quality at the lowest cost. It will also be responsible for finding end uses for new products, and for developing new products to meet specific needs. Operations research techniques will be employed frequently to examine, direct, or evaluate these experimental programs.

Extensive new facilities, to be completed in 1958, are under construction in South Charleston, West Virginia. Expansion of the Development staff is already underway in preparation for the greatly increased activity that these new facilities will make possible. Plans for expansion offer chances for rapid advancement in the Development Department.

Men are needed who can initiate experimental work in the fields of both resins and chemicals, and assume complete responsibility for the prosecution of the experimental programs and for the promoting of development work to follow the experimental studies.

Scientists interested in the following fields will find opportunity and encouragement:

FIELD	REQUIRED BACKGROUND IN:
Chemical Engineering	Operation of pilot plant equipment to provide data for engineering design.
	Process development—design and construction of new chemical engineering equipment.
Organic Chemistry	Organic chemistry, theoretical and practical—synthetic production of aliphatic, aromatic, and metallo-organic chemicals; resins and plastics.
Physical Chemistry	Revelation of polymer structure by physical chemical instrumentation methods—activation of evaluation programs for resinous materials.
	Fundamental approach to problems involving catalysis—experimental actuation of the catalysis involved in such problems.
	Measurement of properties, reaction rates, ionization constants of organic compounds. Design of measurement equipment.
Organic Analysis	Functional group analysis organic chemistry—non-aqueous titrimetry—trace analysis.
Engineering Physics	Physical chemical measurement—methods of testing resins and resin solutions—rheological and other properties of high polymers.
Mathematics	Advanced mathematics and statistical principles—numerical analysis, operations research—statistical analysis of experimental data.

Send a full description of your training and experience to E. J. Mills, Jr.

Development Department
CARBIDE AND CARBON CHEMICALS COMPANY
A Division of Union Carbide and Carbon Corporation
South Charleston, West Virginia

REFINERY ENGINEERING in Southern California

Several qualified graduate engineers – Chemical, Mechanical or Petroleum – can broaden their professional responsibilities in our Chemical Engineering Department.

Assignments will cover the application of processes to a wide variety of industrial plants, ranging from complete integrated refineries and chemical processing centers through all types of individual process units. The work includes coordination of chemical engineering, the selection and design of process equipment and machinery, and startup of completed plants.

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Interesting and challenging opportunities exist in expanding Central Research and Development Laboratory of medium sized company for men with B.S. or M.S. degree. Work consists of laboratory and pilot plant studies in connection with process improvement of existing plant processes and development of new products in fields of inorganic and organic chemistry. Opportunity to obtain broad experience in technical problems of a diversified nature. Send resume to: Frank V. Paley, Professional and Technical Employment Manager,

THOMAS A. EDISON, INC.
WEST ORANGE, N. J.

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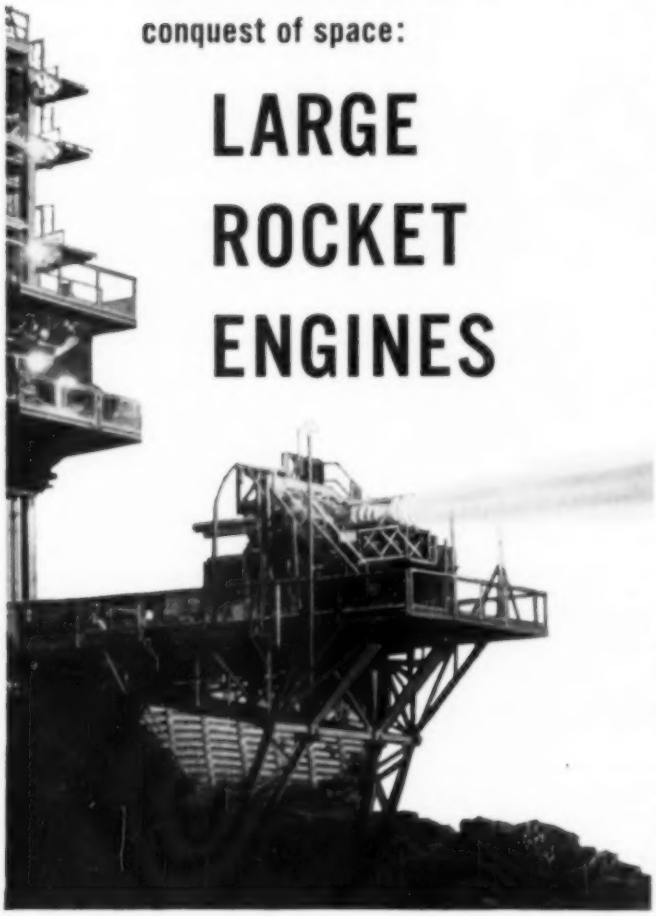

WILLIAM J. CECKA, JR., 35, aeronautical engineer, (Univ. of Minn. '43), was called from North American by the Air Force for experimental rocket work in 1944. On his return, he progressed rapidly: 1948, supervisory test job; 1950, group engineer, operations; 1953 engineering group leader; 1955, section chief of engineering test. Using our refund plan, he has his M.Sc. in sight.

GEORGE P. SUTTON, in the 13 brilliant years since receiving his MSME, Cal Tech, has made rocketry a way of life. His reputation is world wide. His book *Rocket Propulsion Elements* is recognized as the standard text on the subject. Still active academically, but no bookworm, he takes time off occasionally to study the laws of motion at some of the world's better ski resorts.

Tomorrow's count down already fills the air at ROCKETDYNE's 1,600-acre Field Test Laboratory in the Santa Susana Mountains near Los Angeles. For this is the free world's largest workshop for rocket engineering—the great new industry that is now attracting many of the finest scientific and engineering minds in the country.

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INTERESTING BOOKLET: "The Big Challenge"—facts on design criteria and development approaches used at ROCKETDYNE. Write for your personal copy, specifying your degree and years of post-college experience. Address: A. W. Jamieson, Engineering Personnel Dept. 1-CEG, 6633 Canoga Ave., Canoga Park, California.

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- **MECHANICAL ENGINEERING:** To design turbines, pumps, engines and special machinery to operate at extremely low temperatures. To coordinate the manufacture, procurement, installation and operation of large compressors, drivers and other machinery for the processing of gases and liquids.
- **DESIGN ENGINEERING:** Process equipment, pressure vessels, piping, structural, plant layout, electrical, instrumentation.
- **CONSTRUCTION ENGINEERS:** Supervision, start up, and operation.
- **RESEARCH AND DEVELOPMENT:** To explore new horizons in processing and equipment design. Analytical, experimental, design, pilot plants.
- **SALES ENGINEERING:** To negotiate the sale of complete low temperature systems, for chemical, petroleum, metallurgical, industrial and government requirements.

Openings exist for all levels of experience. Training and rotation are provided. High salaries are combined with a profit sharing and bonus program. Professional development is encouraged—growth is continually creating new managerial positions.

This well diversified company offers an unusual challenge for engineers who seek a professional career in the atmosphere of a dynamic, growing company.

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Forward resumes to Personnel Director, The Norwich Pharmacal Company, Norwich, N.Y.

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Bill Milligan, Tucker 1549, Los Angeles, Calif.
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At the country's largest design-engineering center for nuclear power reactors, Bettis Plant in Pittsburgh, operated for the Atomic Energy Commission by Westinghouse, the application of nuclear power has progressed rapidly. However, the nuclear power plants already in operation today represent only the beginning of a new technological era. *Major advances in many areas are necessary.*

These include: work in the fields of plant design, instrumentation, thermal analysis, process or corrosion; experimental or theoretical investigations in heat transfer under both steady state and transient conditions; work with corrosion, particularly with metals in contact with high temperature, high pressure water; design of heat exchangers, pressure vessels . . . to meet the new and severe requirements.

To do this, Bettis Plant needs farsighted men. Regardless of your interest, you can choose a place in the varied operations at Bettis Plant.

Atomic experience is not necessary.

What's more, Bettis Plant is in Pittsburgh's South Hills. Here you can enjoy good living in pleasant suburbs near the plant, and still be convenient to one of the nation's most progressive metropolitan areas.

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Write for descriptive brochure on opportunities in your field. Be sure to specify your interests. Address Mr. A. M. Johnston, Westinghouse Bettis Plant, Dept. A-125, P. O. Box 1468, Pittsburgh 30, Pa.

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With three to six years experience

Several qualified process engineers can broaden their professional responsibilities in our Process Engineering Department. They will design a wide variety of plants for petroleum refining and large volume petrochemical processing.

Assignments range from complete integrated refineries and chemical plants through all types of individual process units. The work includes heat and material balances, and computations for unit operations such as fractionation, heat-transfer, absorption and extraction.

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3M Company's continued research program has created an opportunity in the field of continuous catalytic organic reactions for a chemist or chemical engineer (graduate training preferred but not essential) with 4-5 years' industrial research experience. Location in company's new Central Research Laboratories in St. Paul, Minnesota, provides easy access to the nation's outstanding hunting and fishing areas. Advancement based upon merit. Salary commensurate with training and experience. Write—

Technical Employment Manager
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CHEMICAL ENGINEERS

American Viscose Corporation, a chemical-process industry, has some **permanent** positions open now for **chemical engineers.** To qualify you need a B.S. or M.S. degree from a recognized institution, and, preferably, 3-5 years of experience in process development, product-improvement studies, or chemical engineering 'trouble-shooting' for manufacturing.

The location is in suburban Philadelphia (Marcus Hook) at the **Research and Development Division,** or at one of our seven plants in Pennsylvania, West Virginia, and Virginia.

AVISCO

These openings are technically challenging and offer good advancement opportunities. Interested candidates are invited to submit résumés of personal data, educational history, and work experience to:

Personnel Recruitment Department
AMERICAN VISCOSE CORPORATION
1617 Pennsylvania Boulevard
Philadelphia 3, Pennsylvania

ESSO RESEARCH AND ENGINEERING COMPANY

PROCESS RESEARCH DIVISION

CHEMICAL ENGINEERS for work on

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Here is a unique opportunity for chemical engineers who are interested in research and development in the petroleum industry. A major division of the Esso Research and Engineering Company offers diversified technical work in the application of catalysis to petroleum processing. The jobs involve a combination of desk and pilot plant studies. A broad background in the entire field of developing petroleum processes is afforded through rotational assignment. Excellent growth possibilities in a company pre-eminent in its field.

JOB LOCATION: Linden, New Jersey (20 miles from New York City)

REQUIREMENTS: Chemical engineers at all degree levels. Applicants with experience up to ten years beyond their degree will be considered.

SALARY: Open—related to experience.

Please send a short résumé of educational and experience background. All replies will be considered promptly and held confidential.

Employee Relations—C—Esso Research Center
Esso Research and Engineering Company, P.O. Box 51, Linden, New Jersey

the chemical engineer in

MARKETING

Piper

Eric G. Piper appointed sales manager of centrifugal and filtration equipment at Bird Machine Co., South Walpole, Mass.

New manager of the Philadelphia office of the Foxboro Co., Foxboro, Mass., will be **G. H. Gleason.**

Michigan Chemical Corp., Saint Louis, Mich., appoints **Everett E. Klicker** as sales manager in the Rare Earths and Thorium Division.

Harry F. Ogden, Jr., named district sales engineer in the Philadelphia district by the Sharples Corp.

Atlas Powder Co. announces appointment of **Robert S. First** as manager of the marketing research section in the product development department of its Chemicals Division.

Grant

Dow Chemical announces that **Leo B. Grant,** manager of the New York office since 1949, will fill newly-created position of sales manager of the Chemicals Department, with headquarters in Midland, Mich.

Robert C. Hickerson to staff of the Market Development Department of Tennessee Products & Chemical Corp.

Hooker Electrochemical Co., Tacoma, Wash., names **E. Paul Duncan** as supervisor, technical service.

J. W. Michener named to post of special assistant for engineering sales at Dorr-Oliver, Stamford, Conn.

Ludlow, Jr.

Alden R. Ludlow, Jr., named director of sales for U. S. Industrial Chemicals Division of National Distillers Products Corp.

Organizational changes announced by Buffovak Equipment Division, Blaw-Knox Co., are: **E. L. Demarest,** previously district manager of the Philadelphia Office, transferred to Buffalo as manager of sales; at the same time, **W. D. Kohlins** becomes division manager.

(Continued on page 140)

CHEMICAL ENGINEERING

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in

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Design, development, testing, and operation of nuclear reactors and component parts for research, production, power, and aircraft propulsion.

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Advertisements in the Classified Section are payable in advance at 20¢ a word, with a minimum of four lines accepted. Box number counts as two words. Advertisements average about six words a line. Members of the American Institute of Chemical Engineers in good standing are allowed one six-line Situation Wanted insertion (about 36 words) free of charge a year. Members may enter more than one insertion at half rates. Prospective employers and employees in using the Classified Section agree that all communications will be acknowledged; the service is made available on that condition. Boxed advertisements are available at $17 a column inch. Size of type may be specified by advertiser. Answers to advertisements should be addressed to the box number, Classified Section, Chemical Engineering Progress, 25 West 45th Street, New York 36, N. Y. Telephone: COlumbus 5-7330. Advertisements for this section should be in the editorial offices the 15th of the month preceding publication.

Scientists ...

Engineers

A suggestion from Dr. Robert J. Creagan, Project Manager

Westinghouse Commercial Atomic Power

"The physicist's role in the development of nuclear reactors is in analytical and experimental reactor physics, studying the problems of steady state reactivity and of reactor kinetics.

"In addition, reactor control problems with respect to transients are important. The reactor control must be integrated with the transient response of the entire power plant. Mathematical analysis using analog and digital computers is an important part of the work. We'd welcome an opportunity to discuss these interesting phases of our work with you."

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CAPA—Commercial Atomic Power Activity—is the most dynamic new division at Westinghouse. We're "fluid," not fixed. Supervisory jobs open up fast!

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CHEMICAL & SANITARY ENGINEER—Fifteen years' broad multi-plant experience processing, development, economic evaluations, etc., special knowledge industrial wastes and water. Can manage, develop, multi-plant industrial wastes program; or ability as assistant, or chief engineer. Box 4-1.

CHEMICAL ENGINEER—Ph.D. Ten years' responsible experience process development, development-production-liaison, and plant start-ups. Publications and honoraries. Desire responsible position with definite opportunity for advancement to administrative or management level. Box 5-1.

CHEMICAL ENGINEER—eight years' varied production and technical service responsibilities in chemical and modern petroleum processes here and abroad. Desire responsible position in operations or technical assistance group. Present salary $9500. Age 33, family. Box 6-1.

CHEMICAL ENGINEER—B.S.Ch.E. 1955 Age 23. Nuclear plant design past eighteen months. Seek field work or plant operation chemical or mechanical engineering in Western Europe. Box 7-1.

CHEMIST-ENGINEER—B.S. Married. Ten years' diversified experience in pilot plant operations, field engineering, ion exchange, ore treatment, distillation, and filtration. Desire supervision in development or operations. Present salary $9300. Box 8-1.

CHEMICAL ENGINEER—Age 28. Desire position in atomic energy field. Three years' experience in pilot plant supervision and engineering studies in petroleum field. Box 9-1.

the chemical engineer in MARKETING

(*Continued from page* 139)

David E. Terry will be product manager for an expanded line of General Mills fatty nitrogen compounds, it has been announced by the Chemical Division of General Mills.

General Aniline & Film names **Charles H. Berle** as special projects coordinator in their Dyestuff and Chemical Division.

L. C. Rowson to be assistant manager for the West Coast of the Texas Company's Liquefied Petroleum Gas Sales Division.

Polymer Chemicals Division of W. R. Grace & Co. announces that **Frank A. Connell** is joining their marketing department as technical representative for Polymer's new linear polyolefin resins.

Hill

Bruce E. Hill appointed group leader in market development in the Industrial Chemicals Division of Olin Mathieson Chemical Corp., Baltimore.

NRC Metals Corp., subsidiary of National Research Corp., appoints **Jack W. Blanton** as manager of sales development. Mr. Blanton will concentrate on the development of nonnuclear and commercial applications of zirconium and zirconium chemicals.

Rodney Hunt Machine Co., Orange, Mass., announces appointment of The Process Sales Co., managed by **L. P. Skinner, Jr.**, as representative for Turba-Film Processors and other Rodney Hunt process equipment for Texas and Louisiana.

Skinner

RESEARCH CHEMICAL ENGINEER—M.S. Ch.E., P.E. Twelve years in development of various inorganic processes; research in combustion and high temperature reactions; thermodynamic, process and cost evaluations; pilot plant construction and operation. Available immediately in Long Island and metropolitan New York area. Box 10-1.

B.S.Ch.E. 1950. Age 30, family, veteran. Located in East. Six and one-half years diversified sales, development, design, and operational experience. Desire employment at supervisory level with administrative responsibilities. Base salary $8100. Box 11-1.

Lawrence C. Byck, Jr., named manager of heavy chemical sales for U. S. Industrial Chemicals. Mr. Byck will have responsibility for sales of heavy chemicals, including nitrogen products, phosphoric acid and sulfuric acid.

Byck, Jr.

Winthrop M. Barnes, chemical engineer and market analysis specialist, joins Southwest Research Institute's industrial economics staff as process engineer.

Arthur C. Wicker joins staff of sales department of Tube Turns, Louisville, Ky. Mr. Wicker was formerly with U. S. Plywood Corp.

Necrology

Albert E. White, 72, professor emeritus of mechanical engineering at the University of Michigan and director emeritus of the University's Engineering Research Institute. One of Michigan's outstanding teachers, administrators and research scientists, Professor White made important contributions to engineering education.

Arthur N. Parrett, 60, vice-president in charge of research and development for Rayonier, Inc.

John F. Shea, 51, vice-president in charge of sales for the Becco Chemical Division of Food Machinery and Chemical Corp., Buffalo, New York.

Robert C. Reck, 58, associated with Corn Products Refining Co., Argo, Ill.

Walter S. Rapelje, 73, private consultant.

Emmet F. Hitch, 73, retired, formerly associated with the FOA.

Roger T. Businger, 56, formerly with Pittsburgh Plate Glass Co.

R. W. Titus, 72, consultant, O. M. Scott & Sons Co., Marysville, Ohio.

L. C. Haskell, 67, formerly with Southern Cotton Oil Co., Savannah, Ga.

Donald F. Hinshaw, 36, formerly with Sharples Chemicals Corp.

James F. Olsen, 55, General American Transportation Corp., Chicago, Ill.

E. Jackson Thomas, 41, formerly with Gulf Oil Corp., Pittsburgh, Pa.

WANT TO WRITE, EDIT?

Reporting significant developments in the fast-moving world of chemical engineering can be a fascinating, challenging occupation. If you are a chemical engineer who can write, CEP would like to hear from you to discuss openings.

John Mellecker, Editor, New York, COlumbus 5-7330

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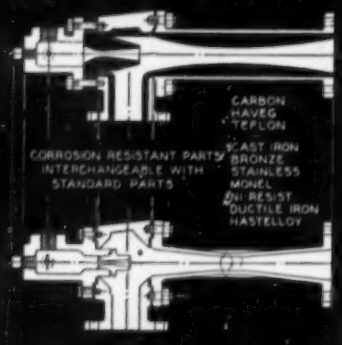

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INDEX OF ADVERTISERS

	Page
Abbé, Inc., Paul O.	86
Ace Glass Incorporated	104
Adams Company, Inc., R. P.	47
Aldrich Pump Co., The	91
Allis-Chalmers Mfg. Co.	9
Alsop Engineering Corp.	122
Amersil Co., Inc.	80
Armstrong Co., Richard M.	32
Artisan Metal Products Inc.	100
Autoclave Engineers, Inc.	50
Ayerst Laboratories	111
Babbitt Steam Specialty Co.	111
Babcock & Wilcox Co.	89
Badger Mfg. Co.	45
Barco Manufacturing Co.	118
Barnstead Still & Demineralizer Co.	127
Bin-Dicator Co.	114
Black, Sivalls & Bryson, Inc.	56
Bowen Engineering, Inc.	69
Cambridge Wire Cloth Co.	121
Carbide & Carbon Chemicals Co. Div. of Union Carbide and Carbon Corp.	Inside Front Cover
Carlson, Inc., G. O.	95
Chempump Corporation	123
Colt's Co., Arthur	112
Cooper Alloy Corp.	43
Crane Company	12
Croll-Reynolds Co., Inc.	79
Crucible Steel Co. of America	71
Davis Sons' Mill Machinery Co., H. C.	142
Davison Chemical Co.	42
Doerr Glass Co.	114
Dow Corning Corporation	130
Downingtown Iron Works, Inc.	78
Doyle & Roth Mfg. Co., Inc.	101
Duraloy Company, The	113
Durametallic Corp.	80
Duriron Co., Inc., The	75
Eastern Industries, Inc.	14
Eco Engineering Co.	58
Eimco Corporation	21
Falls Industries Inc.	108
Fansteel Metallurgical Corp.	120
Firestone Plastics Co.	23
Fischer & Porter Co.	46
Fluor Corp. Ltd., The	64
Foster Engineering Co.	77
Foxboro Company, The	16-17
Frederick Iron & Steel, Inc.	124
General American Transportation Corp., Louisville Drying Machinery Unit	33
Girdler Co., The	
Catalyst Div.	97
Gas Process Div.	34
Glengarry Processes, Inc.	142
Gordon Co., Claud S.	106
Goslin-Birmingham Mfg. Co., Inc.	121
Graham Manufacturing Co., Inc.	59
Graver Construction Co., Inc.	82
Gump Co., B. F.	3
Hardinge Co., Inc.	107
Harshaw Chemical Co.	93
Hilliard Corp., The	62
Illinois Water Treatment Co.	110
Industrial Filter & Pump Mfg. Co.	119
Ingersoll-Rand Co.	27
International Nickel Co., Inc.	53
Jet-Vac Corp., The	142
Johns-Manville	24-25
Kates Co., W. A.	131
Kellogg Co., M. W., The	28-29
Koven Fabricators, Inc.	20
Lapp Insulator Co., Inc.	7, 30
Lawrence Pumps, Inc.	88
Layne & Bowler Pump Co.	60
Lefax Publishers	143
LimiTorque Corp.	73
Lummus Co., The	13
Manning & Lewis Engineering Co.	115
Marley Company, The	55
Metals Disintegrating Co.	2-J
Milton Roy Company	Inside Back Cover
Mixing Equipment Co., Inc.	Back Cover
Monsanto Chemical Co.	48
National Carbon Co., A Div. of Union Carbide and Chemical Corp.	19
National Engineering Co.	92
Newark Wire Cloth Co.	18
Niagara Blower Co.	125
Nichols Engineering & Research Corp.	63
Nuclear Congress 1957	41
Parsons Company, The Ralph M.	6
Permutit Co., The	15
Pfaudler Co., The	99
Philadelphia Gear Works, Inc.	73
Potter Aeronautical Co.	37
Process Filters, Inc.	81
Pulverizing Machinery Div., Metals Disintegrating Co., Inc.	2-J
Read Standard Corp.	44
Republic Flow Meters Co.	57
Roots-Connersville Blower Div. of Dresser Industries, Inc.	39
Ross Heat Exchanger Div.	87
Sargent's Sons Corp., C. G.	129
Schneible Co., Claude B.	124
Schutte & Koerting Co.	11, 105
Sharples Corp., The	31
Shriver & Co., Inc., T.	96
Simpson Mix-Muller Div.	92
Sparkler Mfg. Co.	109
Sparta Mfg. Co.	105
Sperry & Co., D. R.	112
Spindler & Sons, Inc., August	40
Spray Engineering Co.	98
Spraying Systems Co.	105
Stephens-Adamson Mfg. Co.	103
Thermal American Fused Quartz Co., Inc.	106

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	Page
Union Carbide and Carbon Corp. Carbide & Carbon Chemicals Co.	*Inside Front Cover*
National Carbon Co.	19
United States Gasket Co.	10
U. S. Industrial Chemicals Co.	35-36
U. S. Stoneware	51
Vanton Pump & Equipment Corp. Div.	43
Vapor Recovery Systems Co.	126
Vibro Screw	100
Virginia Gear & Machine Co.	73
Wallace & Tiernan, Inc.	128
Watchemoket Optical Co., Inc.	61
Wendnagel & Co., Inc.	110
Wilmad Glass Company, Inc.	131
York Co., Inc., Otto H.	4

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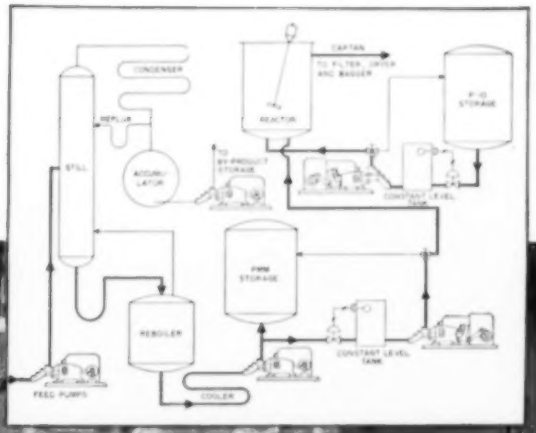
news and notes of A.I.Ch.E.

Boston Meeting: an outstanding success . . . it takes its place as the third largest annual meeting held by A.I.Ch.E. . . . the only larger meetings were in New York. . . . The general committee at Boston under Jim Donovan of Artisan Metal Products did an outstanding job of organization . . . had it not been for a heavy snowfall on Sunday which tied up air transportation, it is believed that this meeting would have been number two in size. . . . The programs at Boston were unique in many respects . . . there was a great variety to suit every kind of chemical engineer . . . (The diversity & pace of A.I.Ch.E. symposia & general technical meetings are ensured for the future, for at the Council meeting & also at the Program Committee meeting Chairman Coulthurst explained a new procedure for the Program Committee which divides it into 18 subdivisions programwise & a quota of symposium & general papers has been set for all subdivisions) . . . This is going to require a great deal of help from the membership but it is the kind of mutual aid that professional men expect to extend to & receive from their fellows . . . If any member has an urge to work on the Program Committee, a note to the Secretary or to either Cotton Coulthurst or Gene Smoley of the Program Committee will bring a response, for some divisions need help. . . . There has been a great deal of activity in the committee structure of A.I.Ch.E., as judged by the chairmen's reports at the Council meeting . . . Professional Development, Career Guidance, Institute Sections, Sections Activities, etc., all reported extensive projects . . . Roy Weston, Chairman of the Pollution Control Engineering Committee, is now working on a manual of methods to control waste . . . Standards Committee has a number of subcommittees investigating standards needed by the chemical field . . . Student Chapters Committee under Brymer Williams issued a report to Council which touched off a debate on how students can be more closely identified with A.I.Ch.E. . . . The determination of such a policy was finally turned over to the Executive Committee. . . . A new A.I.Ch.E. committee appeared on the agenda this year . . . the United Engineering Trustees. . . . Those who have been following the new-engineering-center news will recognize the function of the U.E.T. . . . Our representatives are going to be B. F. Dodge of Yale, L. C. Kemp of Texas Company,

(Continued on next page)

& W. E. Lobo of M. W. Kellogg. . . . Council also concluded its policy discussion on Local Section attitudes toward legislation & a statement will be sent to Local Section officers shortly . . . The debate on divisions within the Institute continued with the result that again Council reaffirmed its previous position that it was in favor of divisions . . . An *ad hoc* committee is continuing its study of the problem of integration with the Program Committee & the policy statement prepared by this committee is to be ready for the January meeting of Council. **Membership is up** . . . Membership plans are extensive for 1957 . . . Local Sections are helping. . . . **Philadelphia-Wilmington Section** now gets out its dues bills on I.B.M. cards . . . Every two weeks during the dues-collection season it runs off on I.B.M. cards the names of those who have paid & these cards are sent to the proper company representative . . . From these he can tell which Local Section member is not fiscally up to date. . . . **Great Salt Lake Section** has a unique arrangement for meals at meetings . . . It specializes in box dinners & offers three choices: chicken, hamburger, or shrimp. . . . **Maryland Section** has recently made a run down of all the members who have served as section officers or have been on the executive committee since 1935. . . . The idea is to back up members' interest with a little historical data so that they may see who has helped the group in times past . . . Sam Streep, secretary, did the work. . . . **New Jersey Section** tried a new idea in programming last season by including planned round table discussions over refreshments following regular meeting . . . Sessions were strictly technical & were planned to extend acquaintance among members interested in the same subjects . . . This was tried at four different meetings, a leader being appointed for each table on such technical subjects as heat transfer, instrumentation, etc. **Student Chapter Counselors:** A. H. Radasch at Cooper Union, H. E. Hoelscher at Johns Hopkins, & John T. Coming at Fenn College. **Career Guidance Committee** has arranged with Vocational Guidance Manuals, Incorporated, to print a manual on vocational guidance in chemical engineering . . . This is essentially the work of Ray Katzen, Vice-chairman of the Career Guidance Committee, & Ray has arranged to have all royalties plus the author's fee turned over to A.I.Ch.E. **Employment Services** at meetings of A.I.Ch.E. have always been on a rather informal hit-or-miss basis consisting mostly of bulletin-board notices . . . There have been some questions concerning this & similar practices of employment at the meetings of professional societies & recently the whole matter was opened up by Council . . . After lengthy discussion, Council asked that meetings of A.I.Ch.E. not encourage formal employment clearing houses & further that the bulletin-board employment notices now being used to some extent by companies attending the meeting be discouraged in the future. **Recently Council** approved a revised statement on research policy (copies are available for those interested) . . . accepted recommendation for Fiftieth Anniversary Committee to interest Post Office Department in issuing commemorative stamp . . . on recommendation of the Student Chapters Committee voted for the establishment of chapters at the Universities of Houston & Mississippi . . . authorized the establishment of the Southern Nevada Section as a Local Section of A.I.Ch.E. . . .& on the important question of the attitude of A.I.Ch.E. toward registration and licensing approved the following: "Professional responsibility for engineering work is a personal responsibility and that personal responsibility should be recognized by all laws relating to the registration or licensure of the professional engineer. There should be no discrimination by implication, omission, or direction as to the form of business organization, individual, partnership, corporation, or other." **1957** is going to be a busy year for A.I.Ch.E. . . . We hope to complete the installation of I.B.M. equipment which will give us directories quicker & cheaper than ever before . . . It will also give us more information on our membership . . . enable us to work more closely with the Program Committee, with the editors, & with other committees in finding men who are expert in particular areas. . . . We are going to have a slogan & medallion-design contest for our 50th Anniversary & the plans for this meeting, which will be held in June of 1958, are shaping up ideally . . . C. G. Kirkbride is committee chairman with Bill Chalfant of the Philadelphia-Wilmington area responsible for planning at the local level. . . . There will be two meetings on top of one another . . . an A.I.Ch.E. Resort meeting at White Sulphur Springs March 3-6 & the Nuclear Congress a week later at Philadelphia. . . . In April there will be a cooperative meeting with the A.S.M.E. on instruments . . . Dave Boyd of Universal Oil Products is caring for A.I.Ch.E. interests . . . In August there will be another cooperative meeting with A.S.M.E. on heat transfer. . . . Our regular meetings will be held at Seattle in June, Baltimore in September, & Chicago in December. . . . **Chairmen of Committees for 1957:** Admissions, Aimison Jonnard; Chemical Engineering Education & Accrediting, R. A. Morgen; Chemical Engineering Education Projects, R. C. Kintner; Constitution & By-Laws, W. E. Lobo; Equipment Testing Procedures, C. H. Brooks; Fiftieth Anniversary, C. G. Kirkbride; Institute Sections, J. C. Dart; Membership, J. J. McKetta; Pollution Control Engineering, R. F. Weston; Professional Development, F. E. Reese; Program, L. J. Coulthurst; Standards, J. C. Lawrence; Student Chapters, Brymer Williams; Symbols & Nomenclature, F. M. Tiller; Career Guidance, M. C. Throdahl. . . . With us now is a **new Assistant Secretary,** Joel Henry, who incidentally is also secretary-treasurer of N. Y. Chapter of the Armed Forces Chemical Association . . . Joel's area will be meetings & membership.

F.J.V.A.



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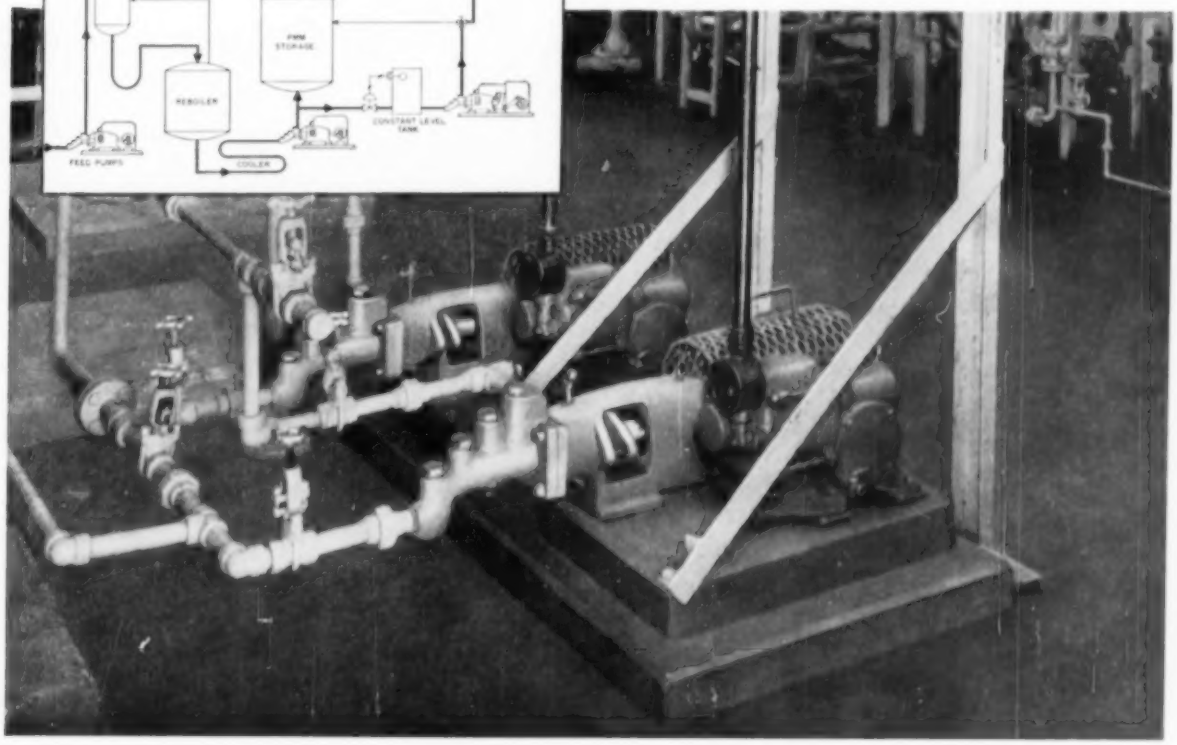

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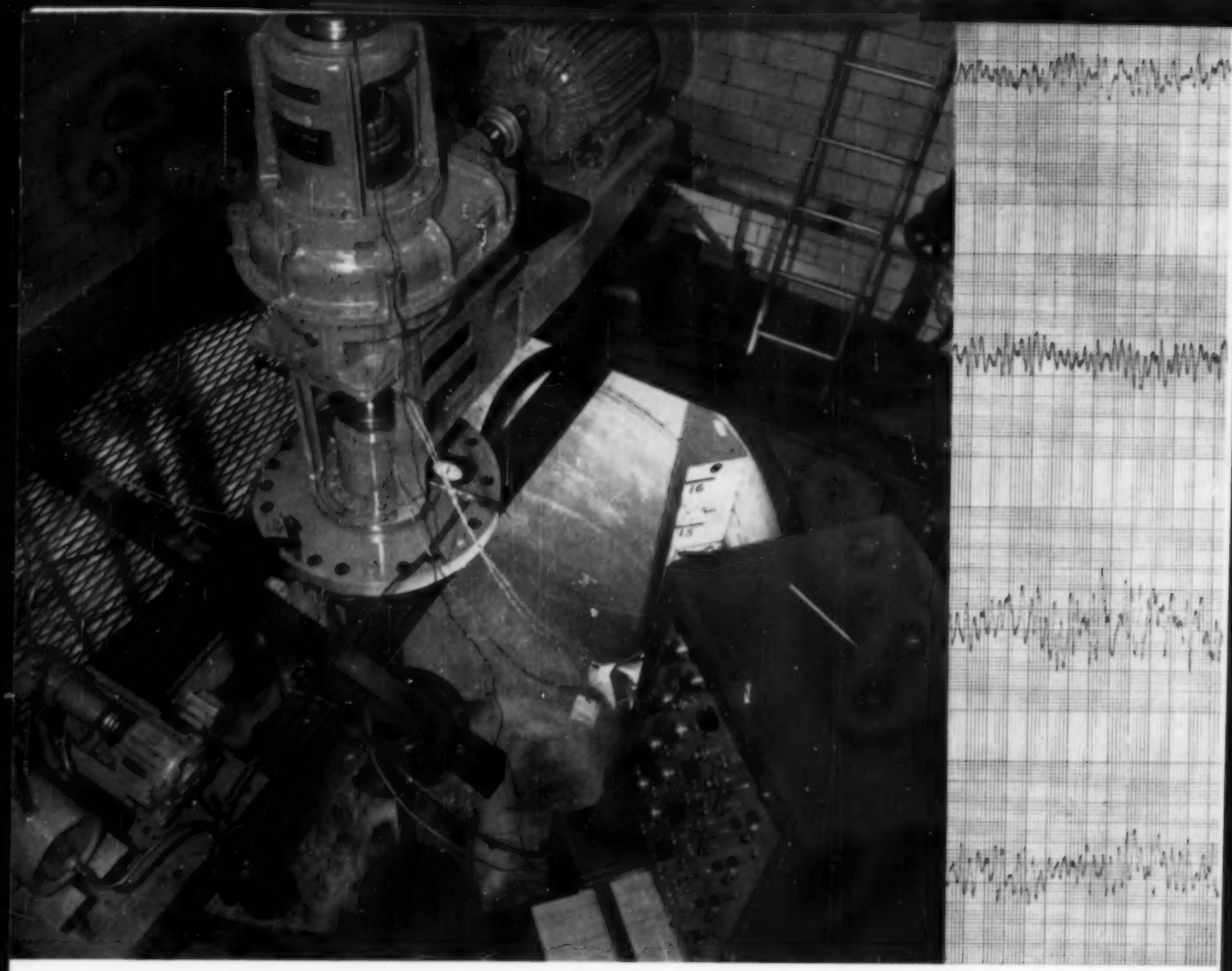

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